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VERIFICATION OF THE PERFORMANCE OF IMPACT LIMITING FINS - II

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Research report

VERIFICATION OF THE PERFORMANCE OF IMPACT LIMITING FINS (PART II)

ABSTRACT

In developing designs of metal crush limiters on special containers for transporting radioactive materials, engineers have on occasion based their calculations on empirically derived design curves. One such set of design curves was developed from drop test experiments at Oak Ridge National Laboratories (ORNL) in 1971.

A study commissioned by the Atomic Energy Control Board repeated the ORNL experimental procedure to check some of the fundamental assumptions inherent in the application of these ORNL design curves. The findings of that study confirmed the validity of the assumptions, however the measurements taken produced a set of curves that differed significantly in magnitude from the ORNL curves.

This report presents the results of a follow-up study that had two principal objectives:

(a) to investigate the influence of impact velocity in order to determine whether it was a cause of the difference between the two sets of curves, and

(b) to extend the range of application of the design curves; specifically to higher deformations, to stainless steel material, and to non-square (oblique) impact conditions.

Using the same drop test facility, instrumentation and experimental procedure as the previous study, data were collected from 272 specimens. These were primarily of the single fin type, similar to the ORNL design; only the oblique impact test specimens had a special double fin configuration.

Results from the impact velocity tests showed that while this did influence the shape of the first part of the curves, it did not explain the difference in magnitude between the two sets of curves.

Changing the fin material to type 304 stainless steel showed that for vertical fins essentially the same curves were obtained. However, for the 30° inclined specimens, the stainless steel fins showed lower energy absorption capabilities.

Measurements from the high deformation tests indicated that there is no tendency for the curves to change slope at the higher deformations.

The oblique impact tests attempted to extend the application of the design curves to a "one end first" type of container impact condition. Results confirmed expected higher values of deformation per input (energy/fin width), but there was no correlation between the curves for normal impact conditions and those for oblique impact conditions.

DISCLAIMER

The opinions expressed in this report are those of the authors and do not necessarily reflect those of the Atomic Energy Control Board.

RÉSUMÉ

En mettant au point les amortisseurs métalliques de certains conteneurs spéciaux de matières radioactives, les ingénieurs ont basé leurs calculs à l'occasion sur des courbes de conception dérivées à partir de faits connus. Une de ces séries de courbes a été mise au point à partir des résultats d'épreuves de chute aux Oak Ridge National Laboratories (ORNL) en 1971.

Par la suite, une étude de la Commission de contrôle de l'énergie atomique a repris les procédures d'expérience des ORNL afin de vérifier quelques-unes des hypothèses de base inhérentes à l'application des courbes de conception des ORNL. Les résultats de l'étude ont confirmé le bien-fondé des hypothèses, bien que les mesures prises aient donné une série de courbes très différentes en grandeur des courbes des ORNL.

Le présent rapport donne les résultats d'un suivi qui avait deux buts principaux :

a) en savoir davantage sur l'influence de la vitesse de l'impact afin de déterminer si c'était là une cause ou non de la différence entre les deux séries de courbes;

b) étendre le champ d'application des courbes de conception, principalement à des déformations supérieures, à des pièces d'acier inoxydable et à des conditions d'impact oblique.

En utilisant la même installation, les mêmes instruments et les mêmes procédures d'épreuve de chute que pour l'étude précédente, les chercheurs ont recueilli des données sur 272 spécimens. Les spécimens comprenaient surtout des modèles à ailette unique, semblable à celles des ORNL; seuls les spécimens soumis à l'épreuve d'impact oblique avaient deux ailettes.

L'étude sur la vitesse d'impact a révélé que la vitesse de l'impact avait une influence sur la forme de la première partie des courbes, mais qu'elle n'expliquait pas la différence de grandeur entre les deux séries de courbes.

On a ensuite changé le matériau des ailettes pour de l'acier inoxydable de type 304, mais les courbes des ailettes verticales sont essentiellement restées les mêmes. Toutefois, pour les spécimens aux ailettes inclinées à 30°, les ailettes d'acier inoxydable avaient une capacité moindre d'absorption d'énergie.

Les mesures des épreuves de grande déformation ont indiqué que les courbes n'avaient pas tendance à changer de pente aux points de déformation plus élevés.

Par des épreuves d'impact oblique, on a essayé d'étendre le champ d'application des courbes de conception à une condition d'impact où le conteneur subit d'abord un choc à une seule extrémité. Les résultats ont confirmé les valeurs de déformation plus élevées prévues par unité, c'est-à-dire l'énergie absorbée par rapport à la largeur des ailettes, mais il n'existe aucune corrélation entre les courbes dans des conditions normales d'impact et dans des conditions d'impact oblique.

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1.0 INTRODUCTION

It is often necessary to resort to empirical data when designing crush limiters for the special containers used for transporting radioactive materials. One of the most widely accepted set of design curves was derived from research work done at Oak Ridge National Laboratories (ORNL) in 1971 [Ref 1].

In 1984, an experimental program was initiated by the Atomic Energy Control Board (AECB) of Canada to check certain aspects of the ORNL empirical design curves. These design curves were derived from tests on standard single fin specimens 2 inches wide and were claimed to be applicable to longer and multiple fin configurations by simple factoring. The results obtained in the experimental program aimed at verifying this assumption [Ref 2] indicated that this was indeed permissible. However, the data gathered by Monserco from duplicate test conditions did not produce curves consistent with the ORNL curves. Basically the Monserco data showed that the amount of energy that must be absorbed by the specimen fins to produce a given percentage deformation, was considerably less that that indicated by the ORNL curves. This was believed to be mainly due to the better data acquisition system used in the later test program.

While this more recent experimental data did extend our understanding of fin behaviour, there remained four areas of response that needed further testing. These were:

1) The effect of impact velocities on energy absorption

2) The effect of using a different fin material

3) The performance of the fins under impact energies close to the capacity of the fins - ie giving large deformation

4) The effect of non-square impact - ie where the impacting surface is not parallel to the top edge of the fin

This report contains results of a second round of drop tests aimed at addressing the above areas of fin behaviour. The work was performed for the Atomic Energy Control Board of Canada by Monserco Limited, Mississauga, Ontario under a contract issued by Department of Supply and Services, Ottawa (DSS File no 55SS.87055-5-4099).

1.1 Note On The System Of Units Adopted In This Report

In this series of experiments, as with the first round of testing, the normal practice of using the SI system of units has deliberately not been followed. Imperial units have been adopted throughout the report to facilitate the comparison of these results with the ORNL data and the earlier results.

2.0 DESCRIPTION OF WORK PERFORMED

2.1 Objectives

As mentioned above there were four main objectives in this second experimental study, all aimed at further testing the validity of the ORNL data and extending our understanding of the performance of welded metal crush limiting fins.

The first objective was to examine whether the impact velocity had a significant effect on the performance of the fins. This question arose while attempting to find possible explanations for the disparity between the ORNL curves and those obtained in the previous series of tests. Although the write-up of the ORNL experiments did not report drop heights - and therefore the impact velocity - for each of the tests, it was thought that if their tests were done from a 30 ft [9m] height, while ours were done from either 7.5 ft [2.25 m] or 1.9 ft [0.6m], this may account for at least some of the difference between the shapes of the two sets of curves. (Drops from heights of 7.5 ft and 1.9 ft give impact velocities of half and quarter of that from 30 ft). Although some brief preliminary tests performed at the start of the previous experimental program did not show any significant sensitivity to impact velocity, it was thought the difference between the two sets of curves was important enough to justify a closer look. Another series of drop tests was therefore performed, wherein the same energy was imparted to the fin specimens at four different impact velocities, varying from 0.5 to 1.0 times the velocity from 30 ft.

A second objective was to determine the influence that changing the fin material would have on the performance of the fins, and hence the shape of the previously obtained curves. The material used in both of the previous studies - ie the ORNL and the first Monserco study - was a mild steel, ASTM A 285, Grade C. The material chosen for this series of tests, having different strength and stiffness properties from the mild steel used previously, was type 304 stainless steel. Similar drop tests were done on a selection of replica ORNL fin configurations.

A third objective was to examine the performance of fin specimens when impacted with energies large enough to cause a high percentage deformation - ie around their damage limit. In the drop tests performed in the previous experimental programme, the hammer energy was controlled to produce about 20 to 50% deformation. (Deformation in this sense is the ratio of deformed fin height to initial undeformed height.) There is a limit to percent fin deformation that is less than 100 % due to the finite thickness of the fin; the limit being dependent upon the mode of fin collapse and might be one, two or three fin thicknesses, depending on the number of plastic hinges that are induced. Of interest here was the shape and extent of the obtained design curves in the upper percent deformation region. Observations from the previous test programme showed that as the fin deforms and the top plastic hinge approaches its limit of deformation, the resistance to further deformation suddenly increases, provided the weld does not fail. If there remains a portion(s) of the fin that

could still deform, it might exhibit a rise in the tail of the curve, somewhat like the ORNL curve in Figure 4. Two sets of test specimens were fabricated to examine this possibility, one for testing at maximum impact velocity (ie 30 ft drops), and the other at half that impact velocity.

A fourth, and final, objective was to extend the range of test conditions defined by the original ORNL test program and investigate fin performance when the impacting surface is not parallel with the top edge of the fin. Such a condition might arise, for example, when a cylindrical container having radial fins attached along its length were to fall "one end first". It was felt that not only was this a more likely mode of impact, but it was important because all of the vessel energy would be borne initially by a small length of fin, rather than distributed along the whole length as previously assumed, and this would result in greater local fin deformation and maybe also peak loading than would otherwise be estimated. This leads to the notion of an "effective" fin length. Impact angles of 10 and 20 degrees to the horizontal were selected for this study.

To this end, four groups of fin test specimens were fabricated, as illustrated in Figures 1 and 2. These specimens were of two basic types:

1) the specimens used for all but the non-square impact tests comprised single fins similar to the ORNL configurations, all 2 inches [50.8mm] wide and of four different heights.

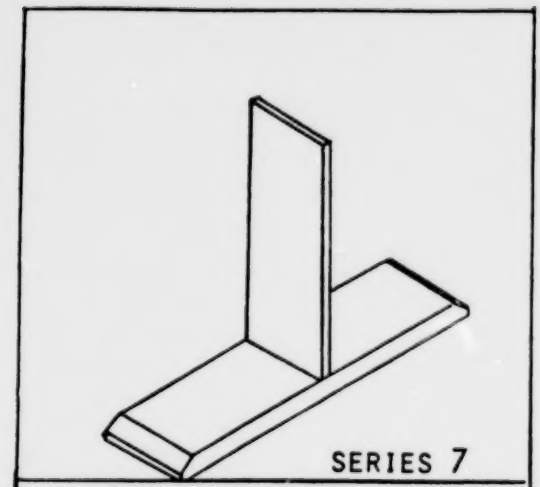
2) the specimens for the non-square impact tests were symmetrical double fin specimens, welded in vertical in-line pairs, with a 3/4 inch gap between the two fins. A double fin configuration was adopted to neutralize the lateral forces that would otherwise be generated.

As in the previous testing programme, the nature of this work was primarily corraborative, with the emphasis being on verifying and extending current knowledge on fin design to aid regulatory staff in their reviewing of container designs. It was not intended to be a piece of original research aimed at generating comprehensive design data curves.

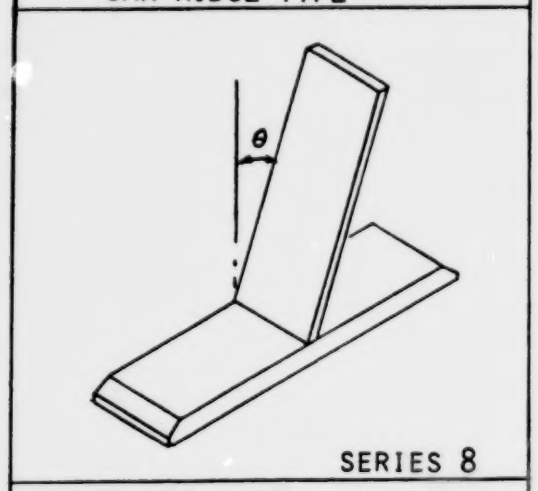
2.2 Test Procedure

As the test procedure adopted in this experimental programme was the same as that followed previously, a detailed description of that procedure has therefore not been repeated here. The reader is referred to the text in section 2.4 of the previous report [Ref 2] for details.

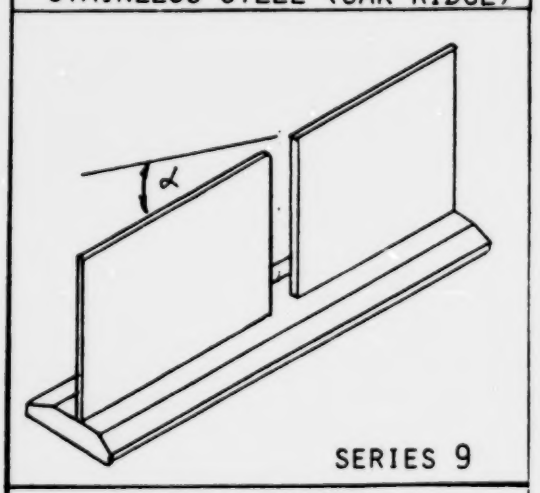
The same drop test facility comprising base, tower, hoist, hammer and load cell arrangement was used, the details of which are described in Appendix A of [Ref 2]. The identical computerized data acquisition system was used, details of which can also be found in the [Ref 2].



OAK RIDGE TYPE



STAINLESS STEEL (OAK RIDGE)



NON-SQUARE (CORNER)

FIGURE 1

CONFIGURATION OF FINS TESTED

2.3 Test Specimens

A total of 272 fin test specimens were fabricated for this second round study. Table 1 summarizes the various combinations of fin dimensions for each test specimen arrangement.

Specimens in each of the four groups were fabricated from 3/8 inch [9.5mm] thick material, and also from 1/4 inch [6.4mm] material for the stainless steel tests and the corner impact tests. In each series there were four different fin lengths between 4 and 10 inches [102 and 254mm]. All specimens comprised a single 2 inch wide fin, except for the corner impact tests which comprised two 6.5 inch fins, 3/4 inch apart. All fins were vertical; in addition the stainless steel series also included a set of specimens with a 30 angle of inclination from the vertical. To lend some statistical significance to the results, at least five specimens of each configuration were fabricated.

All mild steel specimens were fabricated from the same grade of material that was used previously - namely ASTM A 285, Grade C. The yield strength obtained from batch samples of the test material was 39500 psi [273 MPa] for the 1/4 inch [6.4 mm] plate, and 38600 psi [266 MPa] for the 3/8 inch [9.5 mm] plate. These values are close to the corresponding 39860 psi [275 MPa] , and 41380 psi [285 MPa] used previously. For the stainless steel specimens, sample yield strengths were 43800 psi [302 MPa] for the 1/4 inch [6.4mm] plate, and 38135 psi [263 MPa] for the 3/8 inch [9.5mm] plate.

The method of fabricating the fins was the same as in the previous test programme; that is, each of the fins were welded to their bases individually from pre-cut strips held in a jig.

The fin test specimen widths and lengths were accurate to within less than 1/16 inch [1.6mm], and fin thicknesses were approximately 0.010 inches [0.3mm] over the quoted sizes.

2.4 Performance of Tests

As before, the basic approach to testing was to impact the specimens with sufficient energy to produce the desired amount of deformation, which, except for the high deformation series, was in the 20% to 50% range. The objective was to obtain from each group two average curves

(1) absorbed energy/plastic moment versus percent deformation, and

(2) peak force per unit fin width versus fin height/thickness,

and compare with the corresponding curves obtained before.

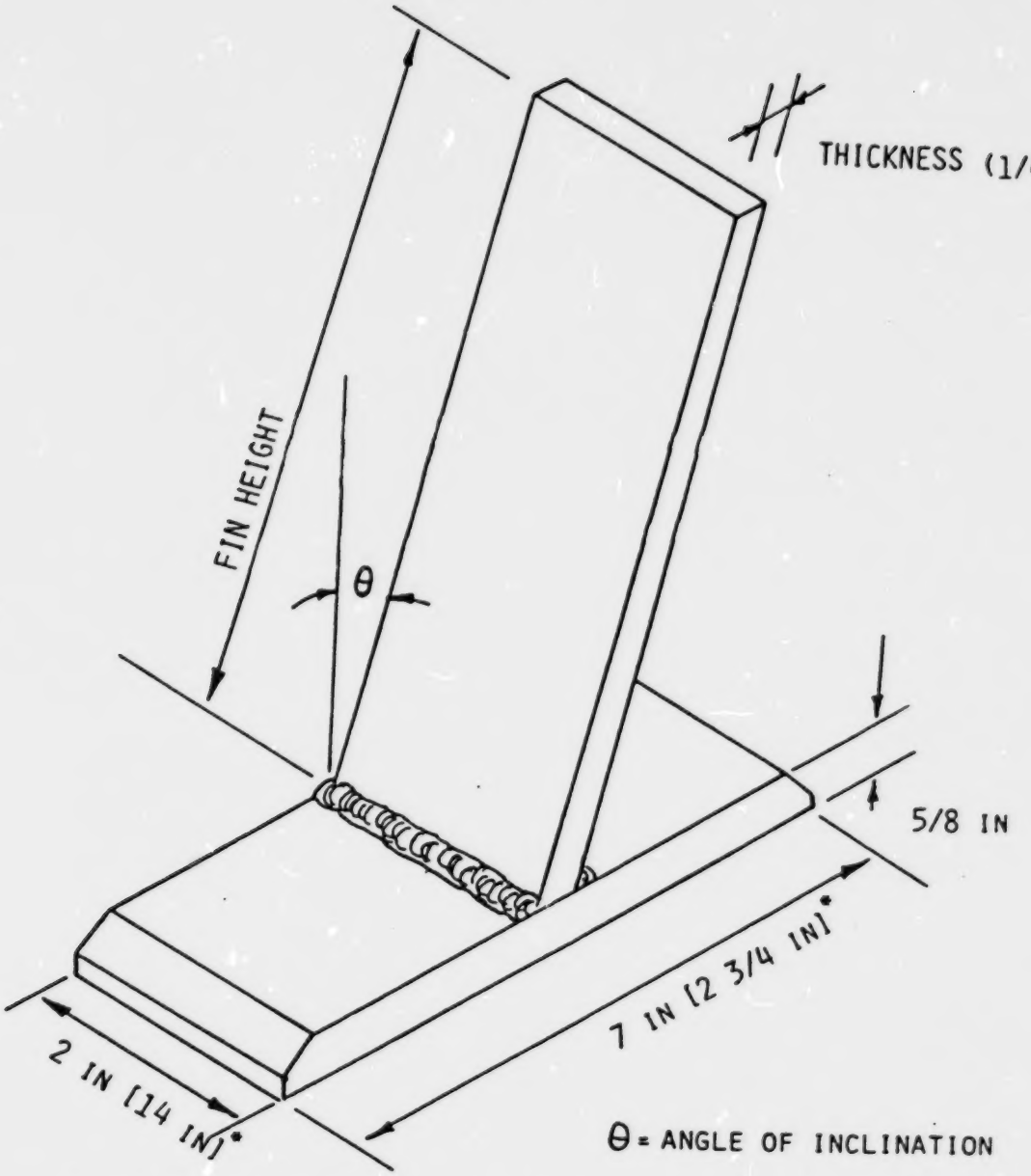
TABLE 1

FIN ANGLE OF INCLINATION (degrees)	FIN LENGTH (inches)	TYPE 7		TYPE 8	TYPE 9	
		(i)	(ii)		(iii)	(iv)
0	4.0	X	X	X	X	X
	6.0	X	X	X	X	X
	8.0	X	X	X	X	X
	10.0	X	X	X	X	X
30	4.0			X		
	6.0			X		
	8.0			X		
	10.0			X		

DIMENSIONS OF FIN SPECIMENS TESTED

Fins were all 0.375 inches thick; Type 8 and Type 9 also included 0.25 inch thick specimens.
At least five specimens of each type were tested.

(i) Impact Velocity Study
(ii) High Deformation Study
(iii) Hammer Face Angle 10 degrees
(iv) Hammer Face Angle 20 degrees



* DIMENSIONS SHOWN IN [ ] APPLY TO THE NON-SQUARE IMPACT SPECIMENS

FIGURE 2

FIN AND BASE DIMENSIONS OF SPECIMENS TESTED

3.0 TEST RESULTS AND EVALUATION

3.1 Methodology for Processing Test Data

The force-time and acceleration-time traces that were captured during the impact of each specimen were processed as before, using the same computer programs, to obtain the energy absorbed by the fin(s), the peak load and the percent vertical fin deformation.

3.2 Presentation of Results

Test results derived from each test specimen have been compiled in a series of Tables, using the same format as in the previous report. The individual tables in each test series are grouped by specimen length and list the basic test parameters (drop height and hammer weight), the measured vertical deformation and some derived results. The derived results that have been tabulated are those that were used to generate the charateristic curves in the previous reports, namely absorbed energy divided by the plastic moment, the percent vertical fin deformation and the peak force divided by the fin width.

Values for the plastic moment were calculated as before from the expression

$$M = y(bt^2/4)$$

where M = static plastic moment of specimen

y = yield stress of specimen material

b = width of fin

t = thickness of fin

In the case of the non-square (corner impact) fins, the width "b" of the plastic hinge is not constant, as the fin is effectively a triangular shaped specimen. For this series then, the plastic moment was computed separately for each specimen from the measured deformation, based on the approximation that the fin hinged along a line parallel to the (inclined) hammer face. Therefore, even though the impact energy may be the same for a test group, the tabulated values for the theoretical (Absorbed Energy/Plastic Moment) are not constant.

3.2.1 Key To Fin Specimen Identification -

The five digit coding scheme used for numbering the various fin specimens in this second round programme is essentially the same as before. The only exception is that the high deformation series has the same first character as the impact velocity series, but is

distinguished by a different fourth character. Only in the stainless steel series, is the fourth character used to identify the angle of inclination of the fin, as previously. For all other series, the fins are vertical and the fourth character has been used to distinguish the other primary test parameter in the series - for example, impact velocity in the group 7 series, and angle of the hammer face in the group 9 series.

The identification code for the first character in this second round of testing is:

FIRST CHARACTER :
- 7 - Oak Ridge Type fins for
  - i) Impact Velocity study
  - ii) High Deformation study
- 8 - Oak Ridge Type fins of Stainless Steel
- 9 - Corner Impact fins

SECOND CHARACTER :
- 2 - Fin Thickness = 0.25" (6.4 mm)
- 3 - Fin Thickness = 0.375" (9.5 mm)

Except for Corner Impact Series, for which:
- 1 - Hammer Face Angle = 10 degrees
- 2 - Hammer Face Angle = 20 degrees

THIRD CHARACTER :
- 4 - Fin Length (Height) = 4.0" (10.16 mm)
- 6 - Fin Length (Height) = 6.0" (15.24 mm)
- 8 - Fin Length (Height) = 8.0" (20.32 mm)
- 1 - Fin Length (Height) = 10.0" (25.40 mm)

FOURTH CHARACTER :

For Impact Velocity Series:
- 1 - Hammer Impact Velocity = 22 ft/s (6.7 m/s)
- 2 - Hammer Impact Velocity = 26 ft/s (7.9 m/s)
- 3 - Hammer Impact Velocity = 33 ft/s (10.1 m/s)
- 4 - Hammer Impact Velocity = 44 ft/s (13.4 m/s)

For Stainless Steel Series:
- 0 - Angle of Inclination = 0 degrees
- 3 - Angle of Inclination = 30 degrees

For High Deformation Series:
- 8 - Hammer Impact Velocity = 22 ft/s (6.7 m/s)
- 9 - Hammer Impact Velocity = 44 ft/s (13.4 m/s)

FIFTH CHARACTER : 1 to 5 - Fin Sample Number

In the computer generated plots stored on the microfiche of load versus time, energy absorbed versus time and (calculated deformation)/(measured deformation) versus time, where the traces of 5-7 specimens in each group are superimposed on one graph, the last character of the identification number has been omitted from the plot heading.

3.3 Evaluation of Results

3.3.1 Effect of Impact Velocity -

In this series of tests, the effect of impact velocity on fin performance was measured on vertical ORNL-type specimens of 4, 6, 8 and 10 inch height. The impact energy was held constant for each group by adjusting the hammer weight and the drop height. Tests were repeated with impact velocities set at 0.5, 0.6, 0.75 and 1.0 times the impact velocity from 30 feet.

The measured and derived results from this series of tests are summarized in the tables at the back of this report. The specimen identification numbers in this series start with 73 and have numbers 1 to 4 for the fourth digit. [The fourth digit distinguishes this series from the High Deformation test series discussed below in Section 3.3.3, which has an 8 or 9 as the fourth digit.]

This series of tests shows that the degree and mode of deformation is influenced by the impact velocity. For the same impact energy, the overall reduction in the fin height (percent deformation) increases as the impact velocity decreases from 44 ft/s to 22 ft/s. The plot in Figure 3 of the measured final percent deformation indicates a roughly linear relationship with impact velocity.

The difference in deformation is due to two effects - a strain rate effect and a deformation mode effect. It is apparent that even at the low impact velocities encountered here, the fin response is more rigid rigid for the higher impact velocities. This is manifested in the decreasing deformation and the increasing peak reaction forces as shown in Figure 3. The mode of deformation is also a contributor, especially for the taller 8 inch and 10 inch specimens. At the lower velocities, there is a tendency for the mode of deformation to be mostly a single plastic hinge in the upper third of the specimen, whereas at the higher impact velocities it is more common to see three more sharply defined plastic hinges, rather like a column buckling with restrained ends. When there is only a single plastic hinge, the fin deformation must be greater to absorb all of the imparted energy.

However, although the results obtained show a measurable effect of impact velocity, this does not account for the difference between the ORNL design curves and the curves derived in the previous round of testing. The effect of impact velocity is to 'broaden' the curves previously obtained - as can be seen in Figures 4 to 7 - but the general shape of the curves remain the same as before. The material stiffening at the higher strain rates increases the slope of the curves at the lower deformations but the curves then follow the same trend as before. The effect does not continue to the extent of matching the increasing trends shown in the ORNL curves.

The peak force per unit fin width also shows a tendency to increase with higher impact velocities, an effect that is consistent with the foregoing discussion. The increase in unit peak force is around 15 % for the short stiff fins, and approximately 6 % for the 10 inch fins. As noted in the previous test programme, the plots of unit peak force versus height/thickness shown in Figure 25 do not bear any correlation with the curve obtained from the ORNL work.

3.3.2 Effect of Fin Material -

This series of tests was effectively a repeat of the tests done previously on ORNL-type specimens, with type 304 stainless steel instead of mild steel specimens. The drop height was the same as before (ie 90.25 inches), but the hammer weights were increased to account for the higher yield strength and to produce a higher percent deformation on the some of the vertical specimen tests. Final deformations for the 30 degree inclined specimens were within the range obtained previously.

The derived results from the vertical fin tests correlate closely with the curves obtained from the corresponding tests done previously, as shown in Figures 8 to 11. Only the curve for the 3/8 inch thick, 4 inch high vertical fins deviates significantly from the previously obtained curves. The reason for this is not apparent. Otherwise, these results show that a change of material from mild steel to stainless steel does not have a significant effect on the design curves for vertical fins.

There is a significant and consistent difference between the (absorbed energy)/(plastic moment) curves for the 30 degree inclined stainless steel specimens tested previously. The results plotted in Figures 12 to 15 show the stainless steel specimens have a lower energy absorption capacity for any given deformation. The data follows a trend as obtained previously, and is some 3 times lower than the ORNL values.

The unit peak force values for the 30 degree inclined stainless steel specimens agree more closely with sthe ORNL curve - see Figure 26.

3.3.3 High Deformation Results -

In this series, impact energies were adjusted to produce a height reduction around 70 %. Two series of tests were performed; one with the drop height set at 30 feet -ie maximum impact velocity, and the other with the drop height set to produce half that impact velocity. The impact energies for the two groups were not the same.

The results plotted in Figures 16 to 19 show that there apparently is not any tendency for the curve to increase in slope at the higher deformations. For all but the 10 inch fins, there again is good

correlation between the results from each of the two series of tests, although not such good agreement with the previously obtained curves. As many of these specimens failed in the weld region - a phenomenon not observed frequently before - the accuracy of these results must be suspect.

3.3.4 Non-square Impact Behaviour -

A few preliminary drops with the 20 degree hammer on double fin specimens, soon showed that the impact energy of hammer would have to be limited in order to reduce the maximum deformation compared to the other tests. At the higher deformations, the impact energy was not always absorbed symmetrically, due to the mode of deformation and the narrow hammer face. On impact, the hammer energy was first absorbed by localized flattening of the top inner corners of the double fins, and then by a plastic hinge as the two fins curled, rather like the corner of a page. The 3/8 inch thick specimens, being more rigid, showed a more predominant flattening, while the 1/4 inch thick specimens tended to curl more. The curling was mostly in the same direction, but sometimes one corner would curl forward and the other backward. Residual impact energy after this initial local deformation was absorbed by additional bending at the root to the fins. Bending at the root displaced the tip of the fin forwards (or backwards), and if this became significant, especially with the longer 8 and 10 inch fins, one or both fins would no longer be in contact with the hammer face. This resulted either in one fin absorbing most of the energy, or the hammer spreading the fins (one forward, one backward) and then slipping between them - a mode of energy absorption that was not representative of an impact with a large flat surface. Time and technical constraints prevented the redesign and fabrication of a hammer with a large enough face, so these tests are confined to the non-square impact response under only relatively small deformations.

With the fin deformation not being uniform across the width of each half of the specimen, it was necessary to devise a different way of measuring the amount of deformation. Based on observations of the mode of deformation described above, a measure of the deformation was taken from the percent reduction in height of the upper triangular portion of the fin, as indicated in Figure 20. Thus according to this scheme, 100 % deformation would correspond to the hammer descending to a point where the hammer face coincides with the baseline indicated in Figure 20.

This effective triangular shape of fin means that the width of the plastic hinge varies and thus the plastic moment is not constant, as in the other test series. The hinge width for computing the 'theoretical' plastic moment was taken as the width of the triangle baseline (ie the hypoteneuse) derived from the actual measurement of the final rest position of the hammer above the specimen base. Thus although the drop height and hammer weight were the same in a test group, the plastic moment applied to obtain the results listed in the tables was not necessarily the same for each test.

The values of E/M computed as described above have been superimposed on the corresponding plots obtained from the normal impact tests done previously, as shown in Figures 21 to 24. For the shorter series of fins, the results for both sets of impact angles are in reasonable agreement. The plots indicate, as might be expected, that when the impact is at an angle so that is not evenly distributed along the top edge of the fin, a greater amount of deformation results.

The two sets of longer fins were also quite consistent, except for the 1/4 inch + 20 degree impact series

Plots of the unit peak force, in Figure 25, show a marked difference with changing impact angle. The effective fin width used in the computation of the tabulated unit peak forces was in each case 20 percent of the plastic hinge width derived from the final hammer displacement.

4.0 CONCLUSIONS

1. It is clear that the response of a fin is influenced by the velocity of impact. For a fixed impact energy, and diminishing impact velocities below 44 ft/s down to 22 ft/s, the resulting deformation increases. Peak forces also show a similar dependency. However, these variations do not on their own explain the difference between the ORNL design curves and those computed in the previous round of experiments.

2. Changing the fin material from mild steel to 304 stainless steel has no significant effect on the performance of vertical fins, where the mode of energy absorption is by multiple plastic hinges. However, in the case of 30 degree inclined fins, where there is only one hinge, the stainless steel displays a much lower absorbing capability.

3. The shape of the E/M versus percent deformation curves obtained from tests to high deformations shows no change in trend.

4. When the impacting surface is not square with the top of a fin, the resulting deformation and peak force tends to be higher. For longer fins and more acute impact angles, these might be significantly greater.

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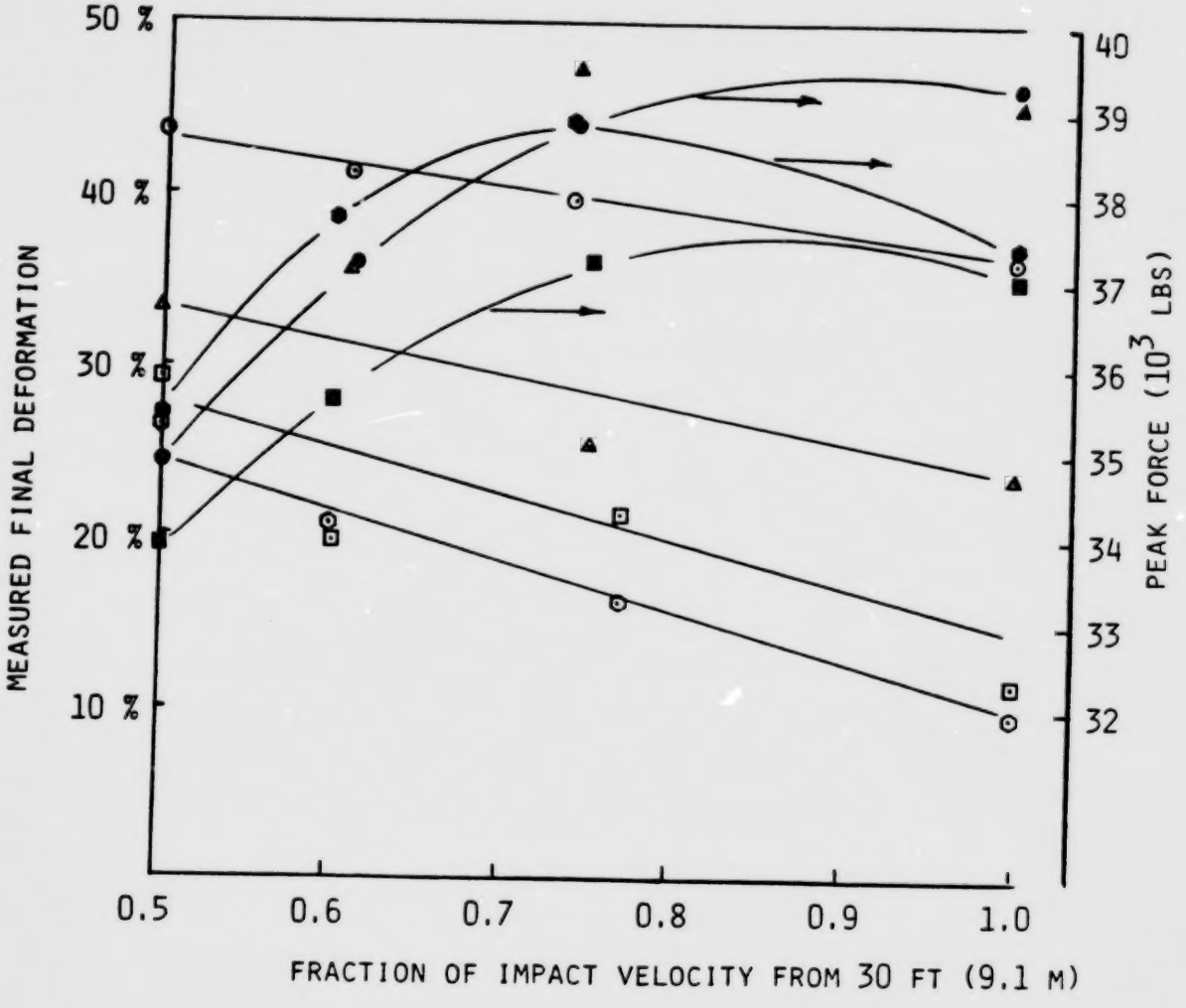
VARIATION OF FINAL MEASURED DEFORMATION
AND PEAK FORCE WITH IMPACT VELOCITY



⊙ 10" FIN
△ 8" FIN
⊡ 6" FIN
⊙ 4" FIN

FIGURE 3

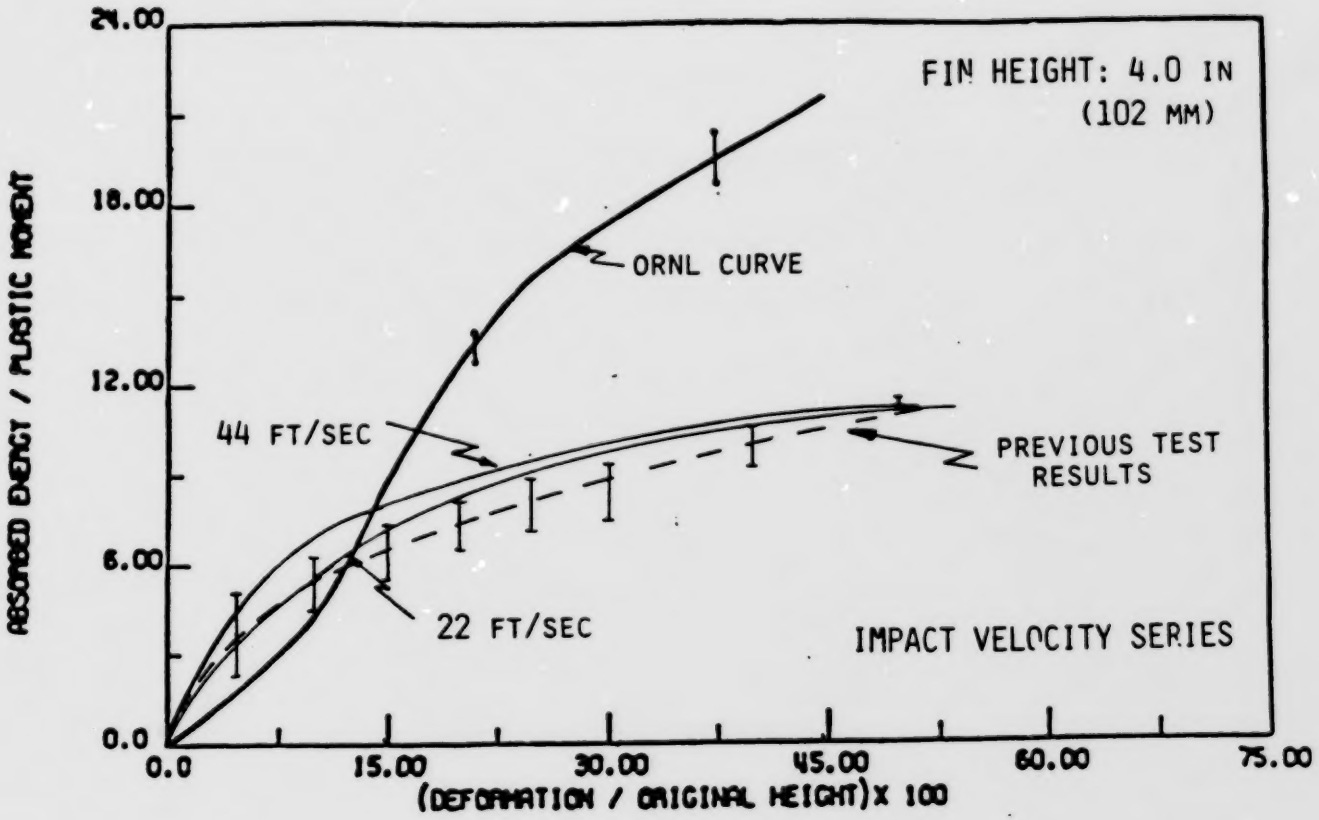


FIGURE 4

The Absorbed Energy Derived From Load Cell Test Data Divided by the Plastic Moment as a Function of the Percentage of Deformation Experienced by Impacted Specimens With a ZERO-Degree Angle of Inclination.

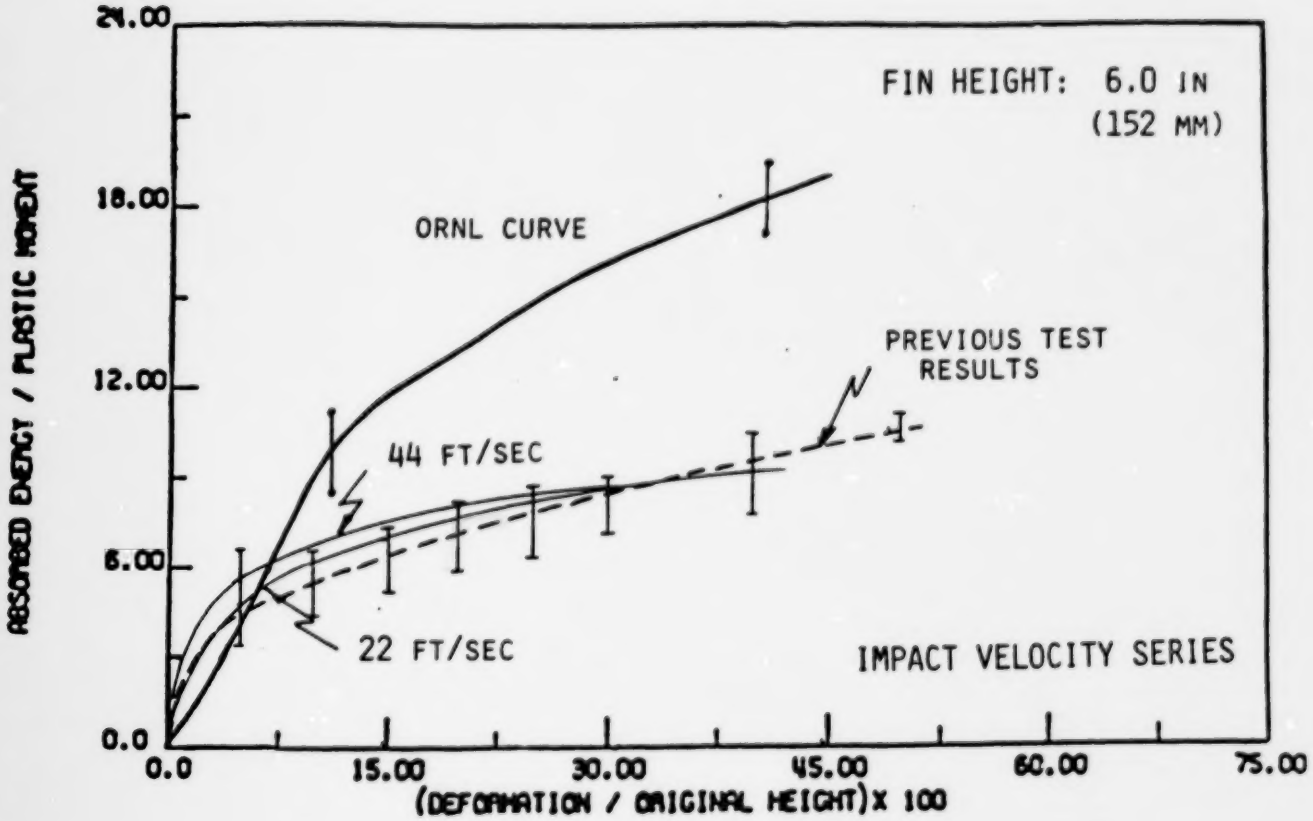


FIGURE 5

The Absorbed Energy Derived From Load Cell Test Data Divided by the Plastic Moment as a Function of the Percentage of Deformation Experienced by Impacted Specimens With a ZERO-Degree Angle of Inclination.

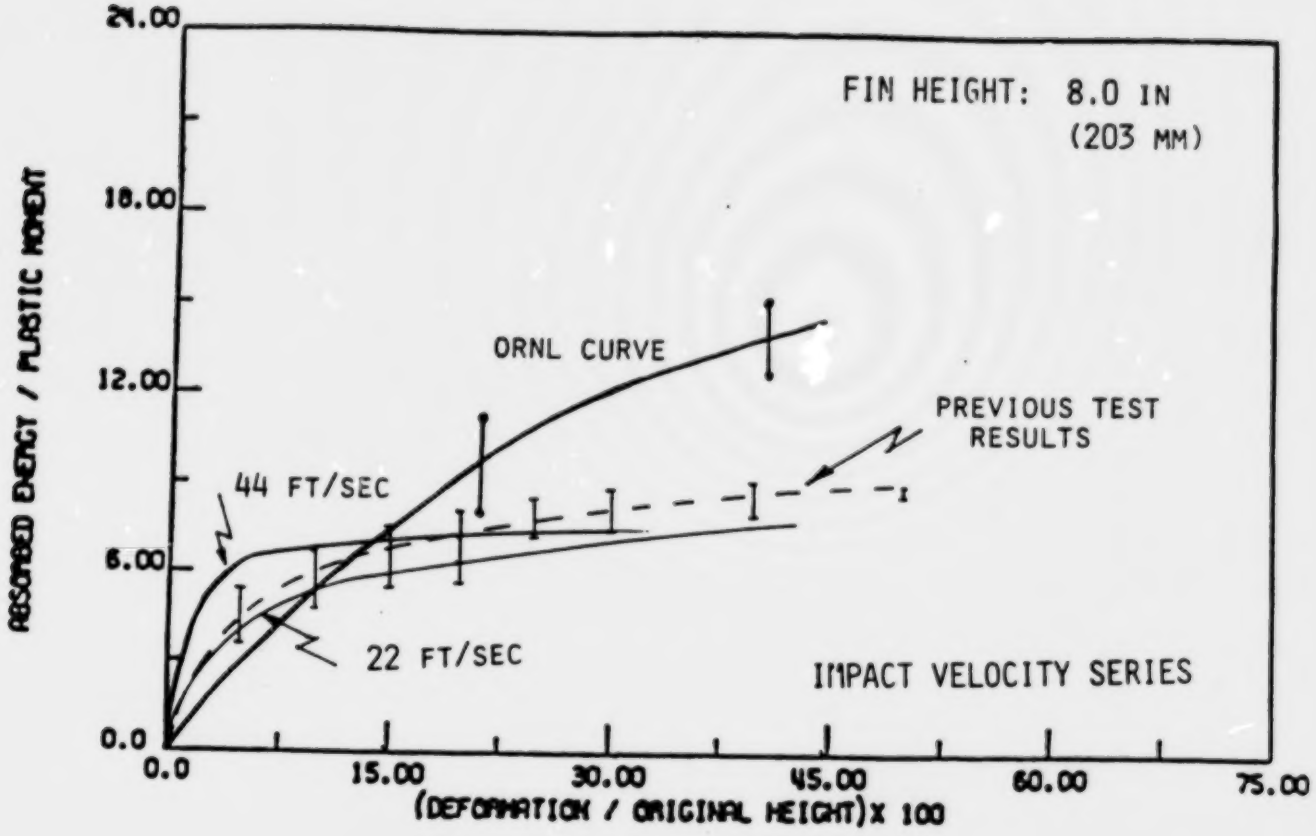


FIGURE 6

The Absorbed Energy Derived From Load Cell Test Data Divided by the Plastic Moment as a Function of the Percentage of Deformation Experienced by Impacted Specimens With a ZERO-Degree Angle of Inclination.

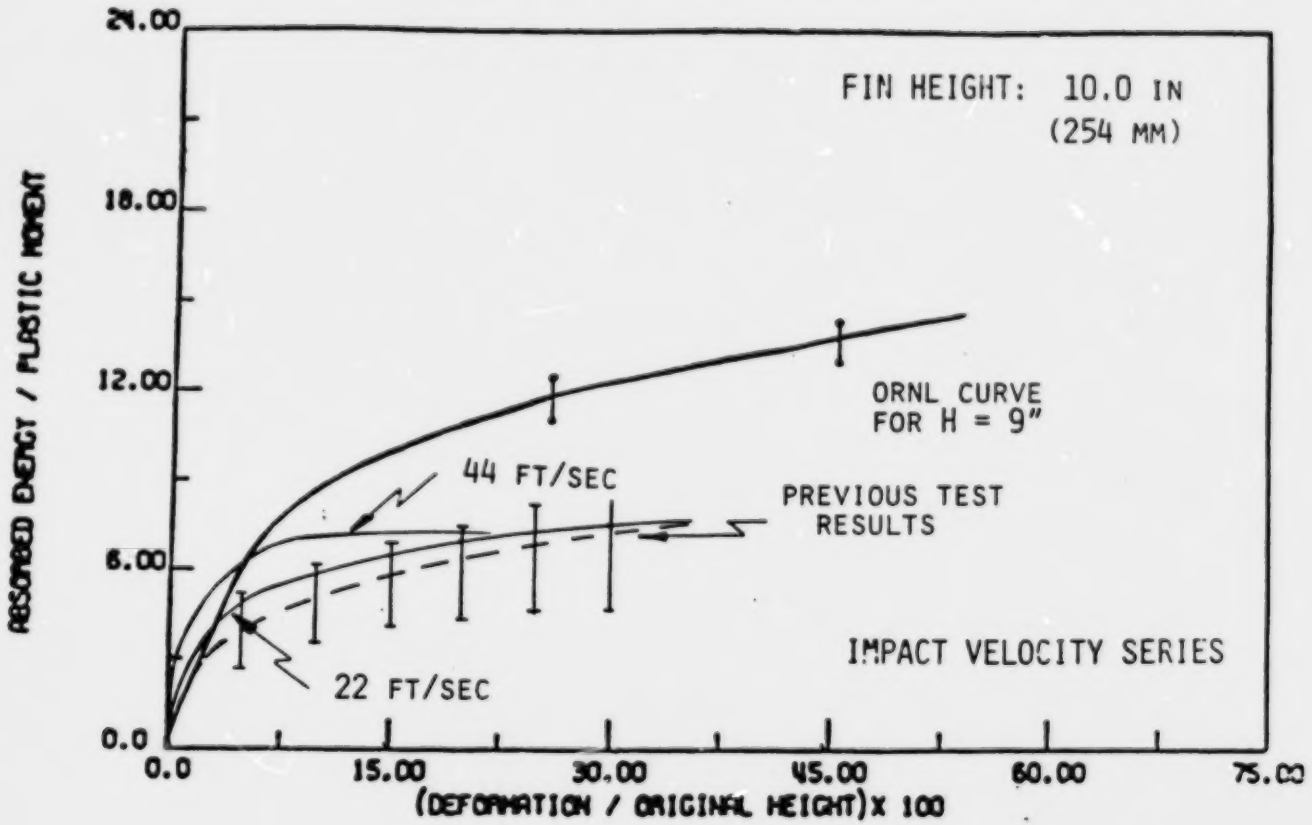


FIGURE 7

The Absorbed Energy Derived From Load Cell Test Data Divided by the Plastic Moment as a Function of the Percentage of Deformation Experienced by Impacted Specimens With a ZERO-Degree Angle of Inclination.

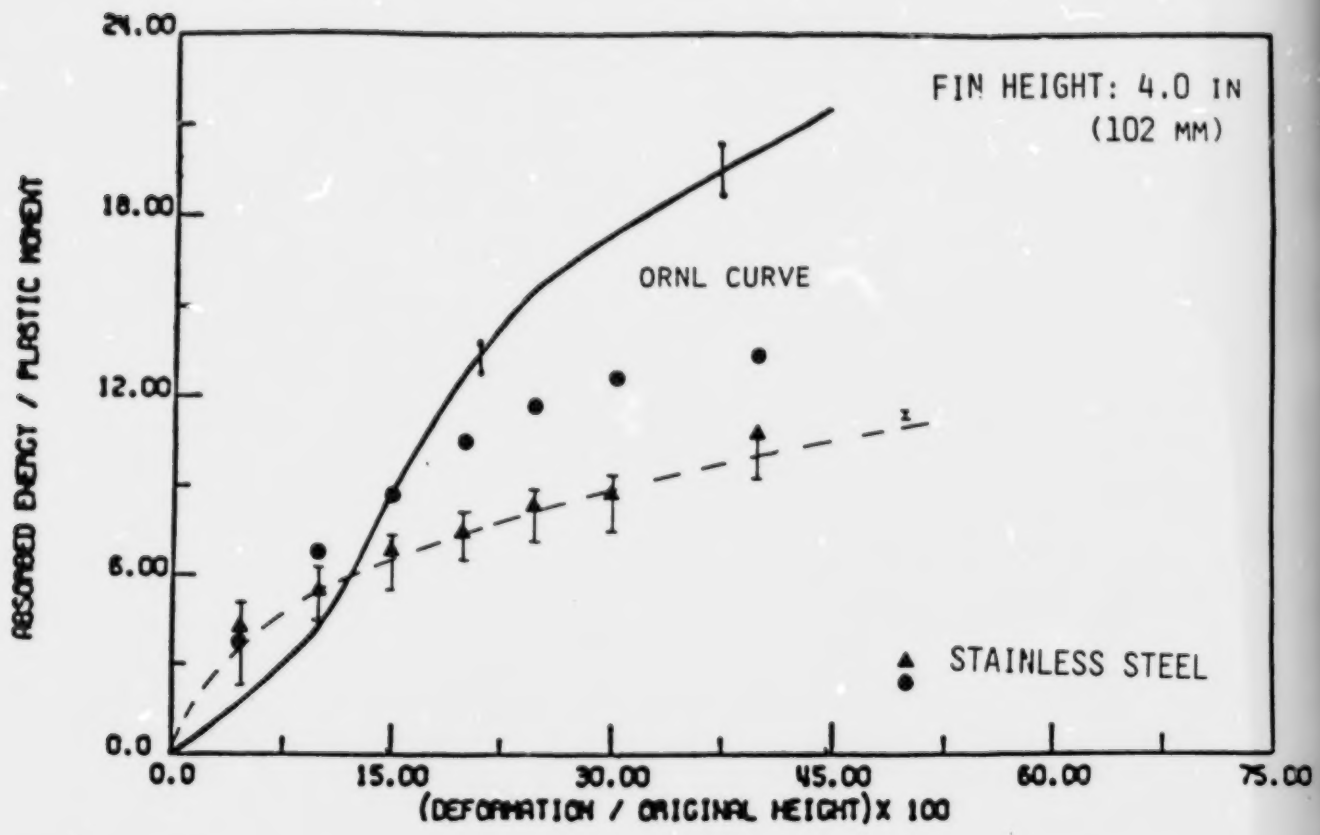


FIGURE 8

The Absorbed Energy Derived From Load Cell Test Data Divided by the Plastic Moment as a Function of the Percentage of Deformation Experienced by Impacted Specimens With a ZERO-Degree Angle of Inclination.

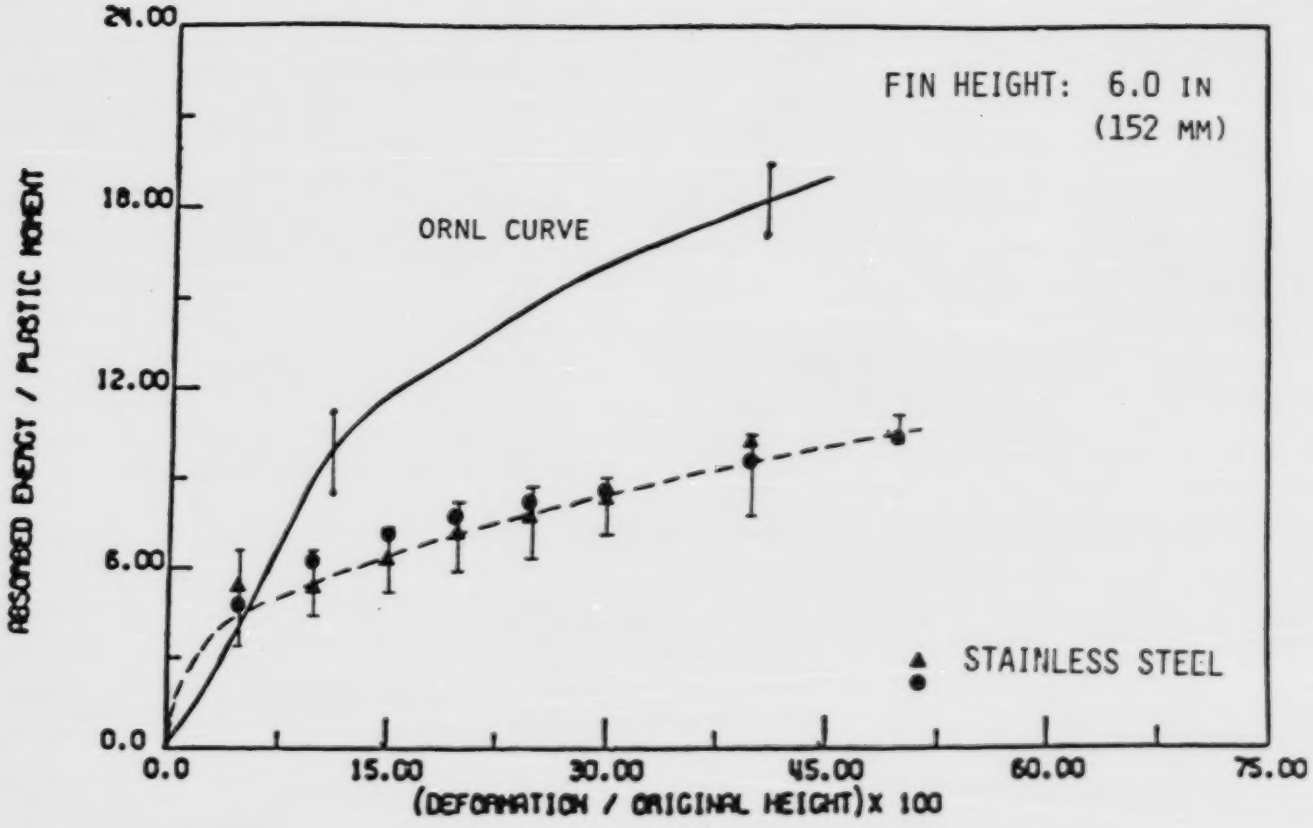


FIGURE 9

The Absorbed Energy Derived From Load Cell Test Data Divided by the Plastic Moment as a Function of the Percentage of Deformation Experienced by Impacted Specimens With a ZERO-Degree Angle of Inclination.

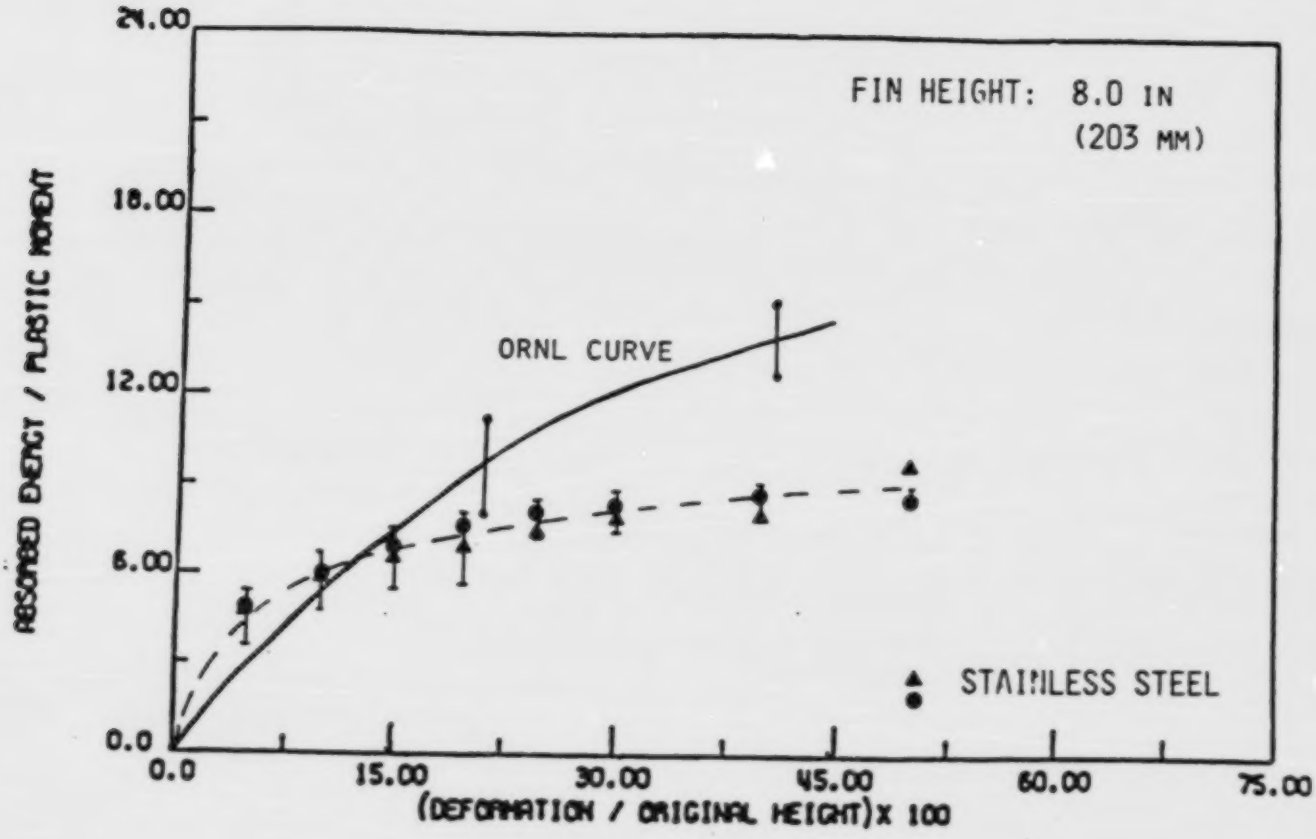


FIGURE 10

The Absorbed Energy Derived From Load Cell Test Data Divided by the Plastic Moment as a Function of the Percentage of Deformation Experienced by Impacted Specimens With a ZERO-Degree Angle of Inclination.

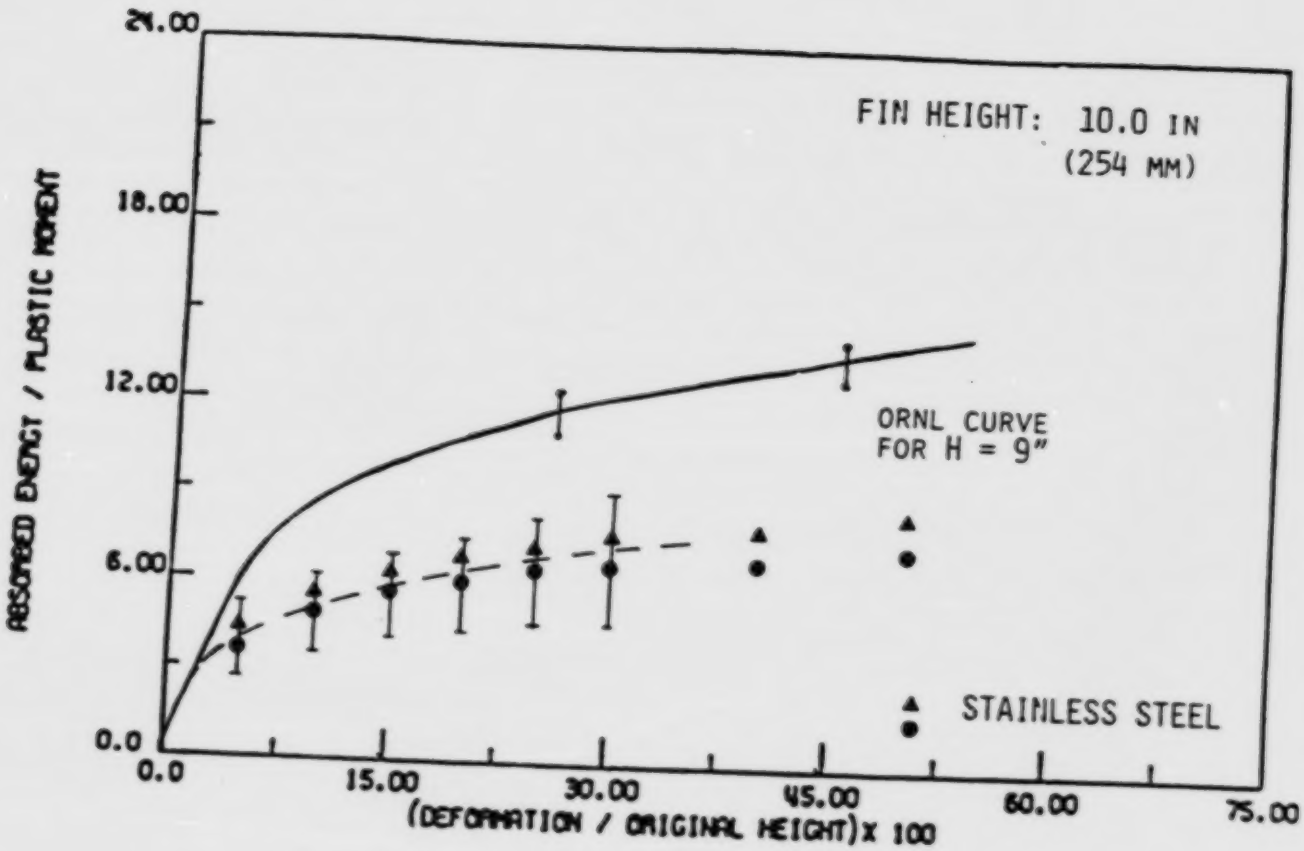


FIGURE 11

The Absorbed Energy Derived From Load Cell Test Data Divided by the Plastic Moment as a Function of the Percentage of Deformation Experienced by Impacted Specimens With a ZERO-Degree Angle of Inclination.

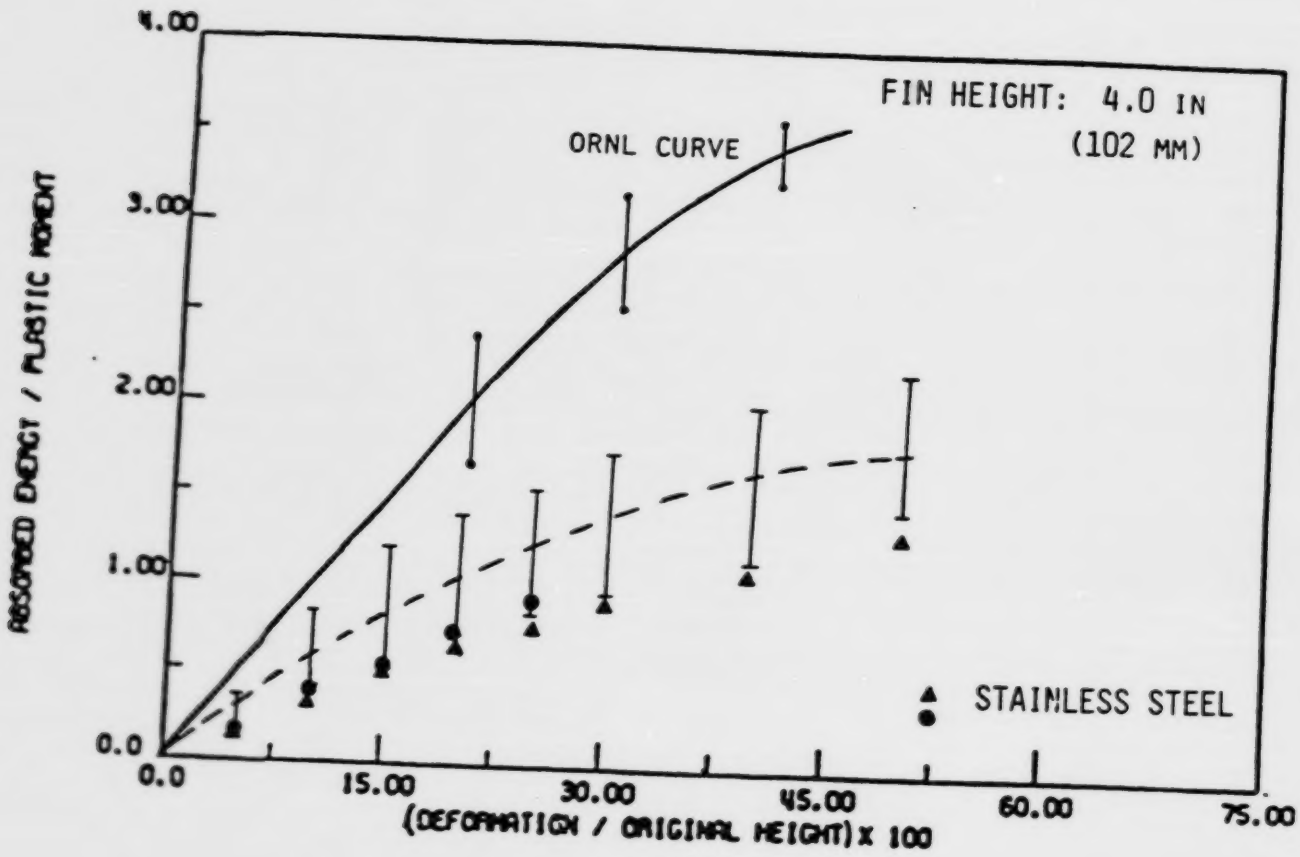


FIGURE 12

The Absorbed Energy Derived From Load Cell Test Data Divided by the Plastic Moment as a Function of the Percentage of Deformation Experienced by Impacted Specimens With a THIRTY-Degree Angle of Inclination.

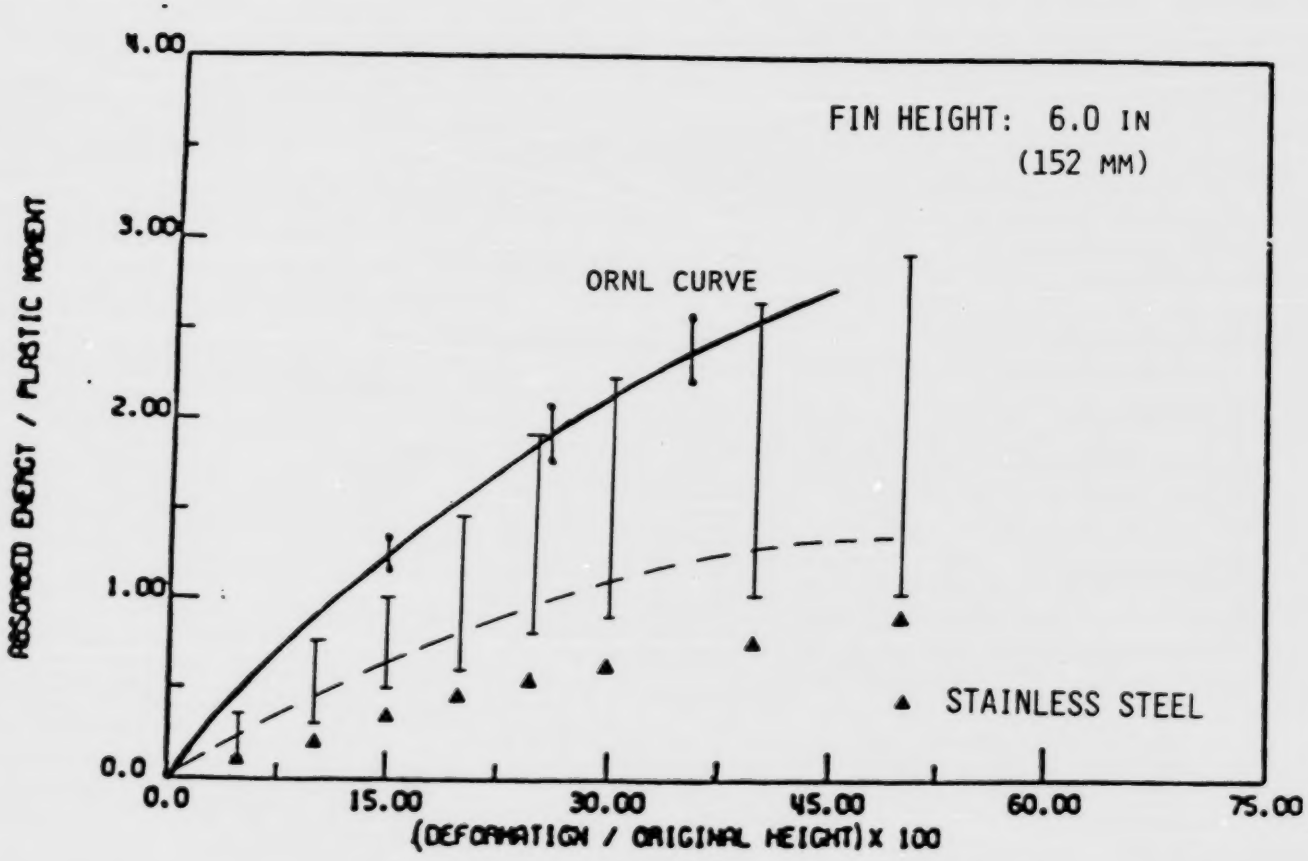


FIGURE 13

The Absorbed Energy Derived From Load Cell Test Data Divided by the Plastic Moment as a Function of the Percentage of Deformation Experienced by Impacted Specimens With a THIRTY-Degree Angle of Inclination.

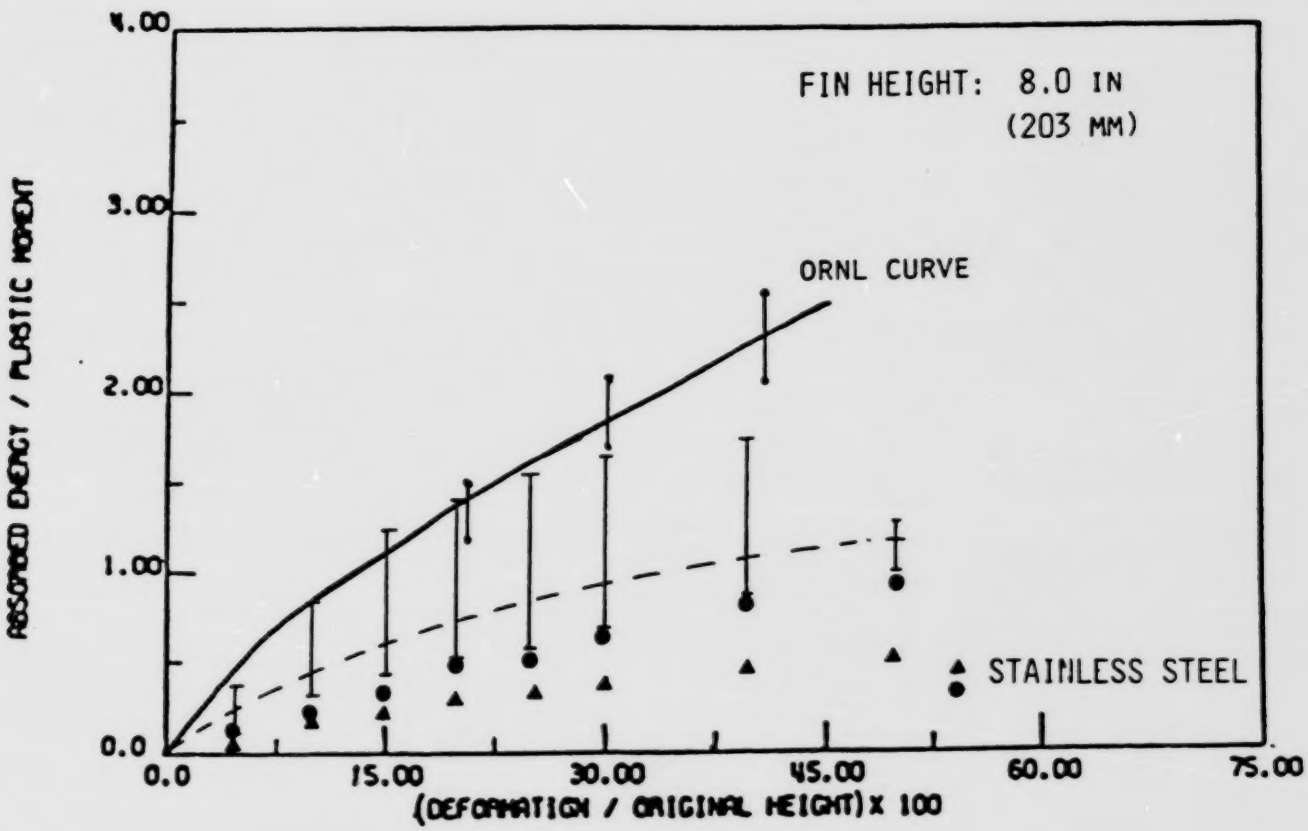


FIGURE 14

The Absorbed Energy Derived From Load Cell Test Data Divided by the Plastic Moment as a Function of the Percentage of Deformation Experienced by Impacted Specimens With a THIRTY-Degree Angle of Inclination.

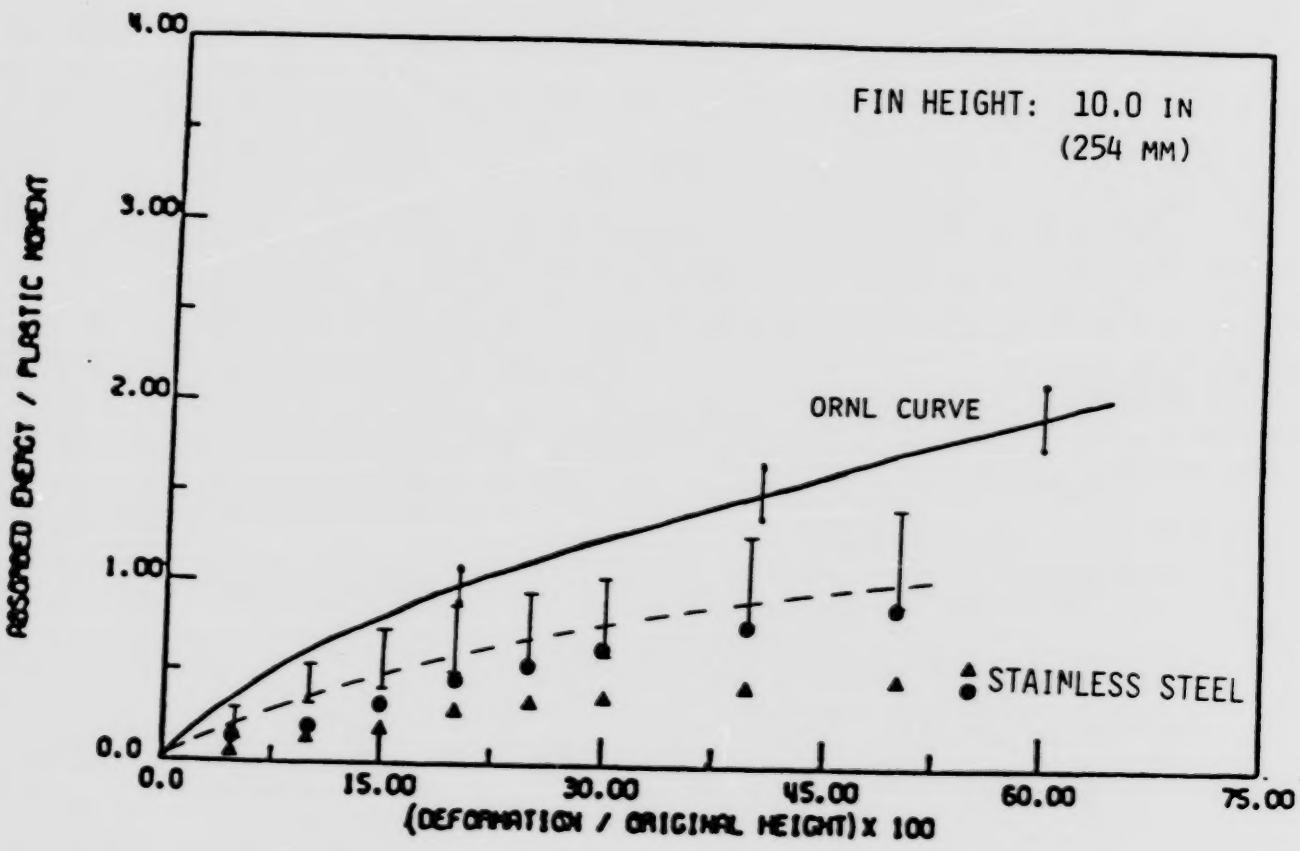


FIGURE 15

The Absorbed Energy Derived From Load Cell Test Data Divided by the Plastic Moment as a Function of the Percentage of Deformation Experienced by Impacted Specimens With a THIRTY-Degree Angle of Inclination.

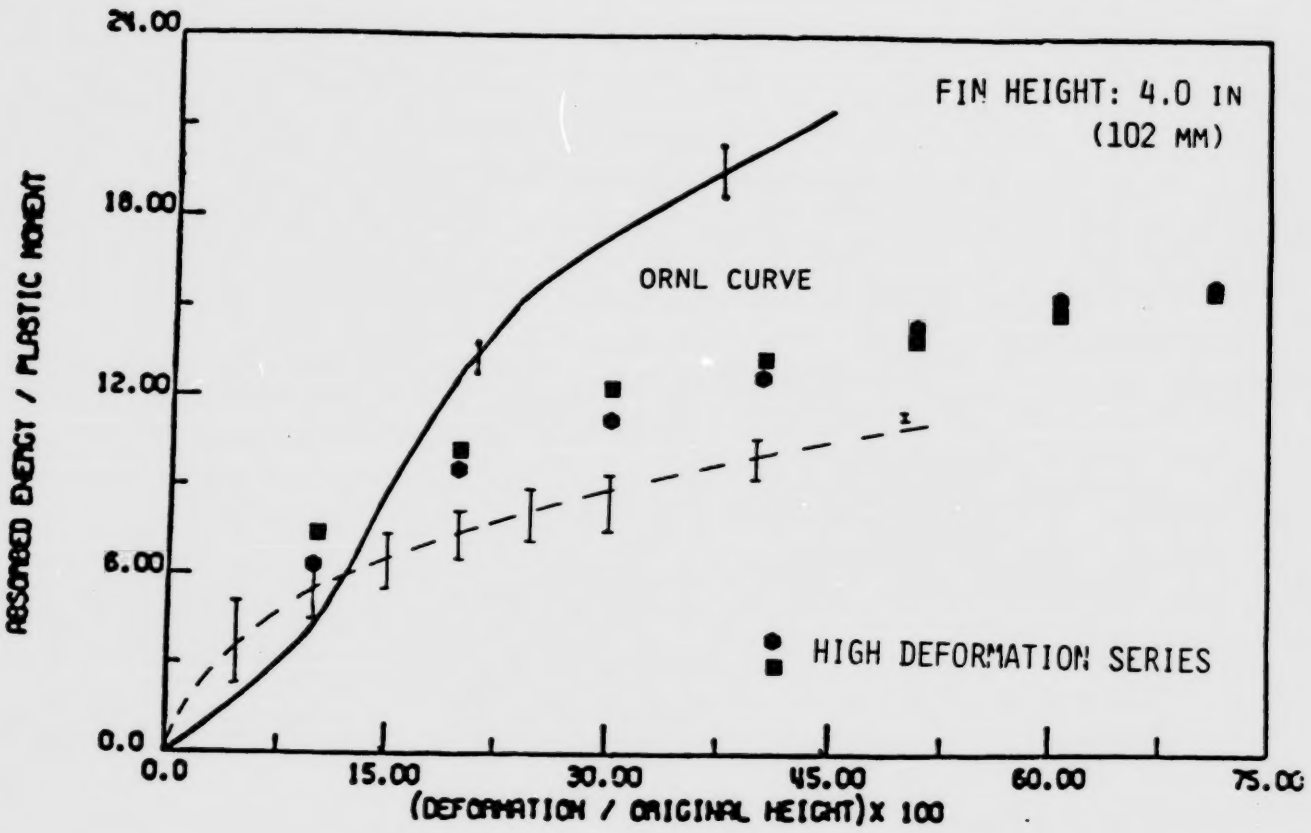


FIGURE 16

The Absorbed Energy Derived From Load Cell Test Data Divided by the Plastic Moment as a Function of the Percentage of Deformation Experienced by Impacted Specimens With a ZERO-Degree Angle of Inclination.

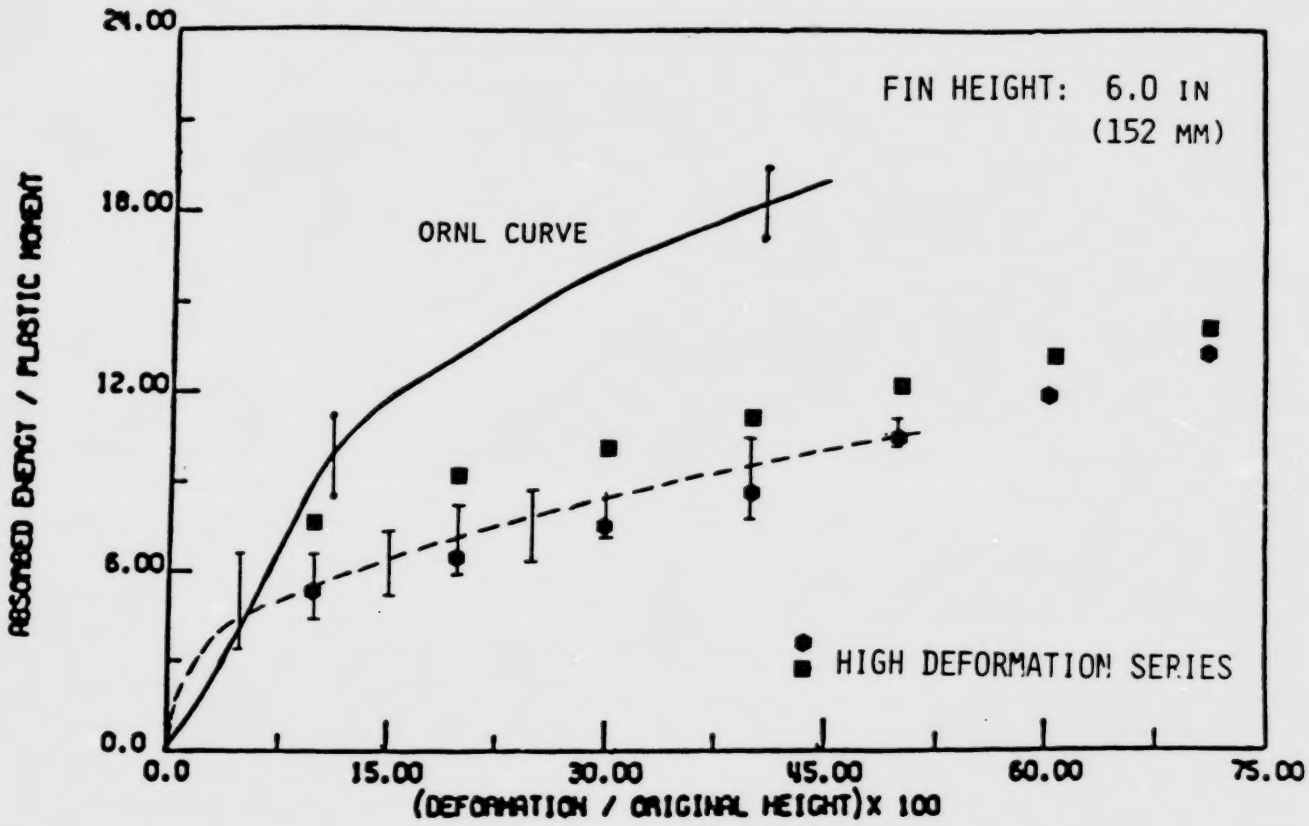


FIGURE 17

The Absorbed Energy Derived From Load Cell Test Data Divided by the Plastic Moment as a Function of the Percentage of Deformation Experienced by Impacted Specimens With a ZERO-Degree Angle of Inclination.

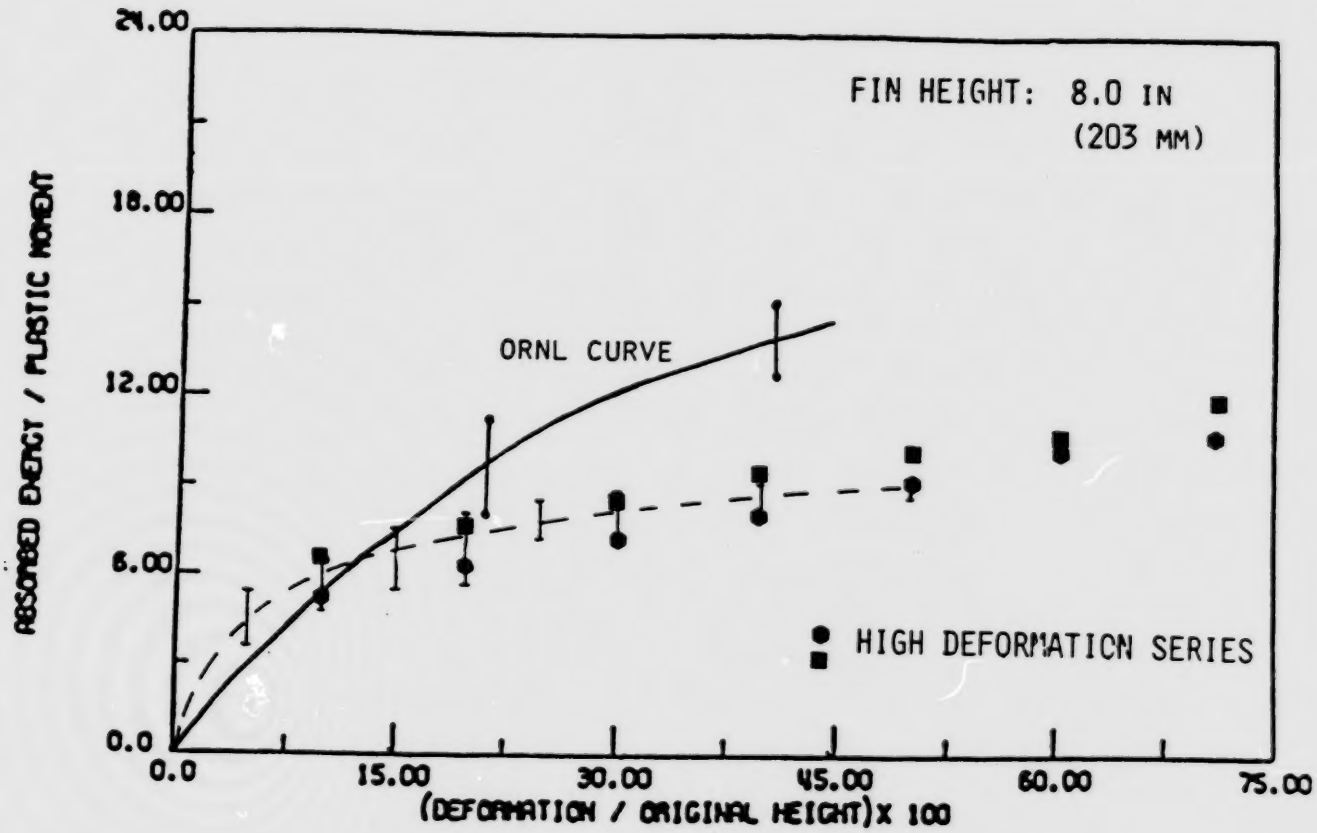


FIGURE 18

The Absorbed Energy Derived From Load Cell Test Data Divided by the Plastic Moment as a Function of the Percentage of Deformation Experienced by Impacted Specimens With a ZERO-Degree Angle of Inclination.

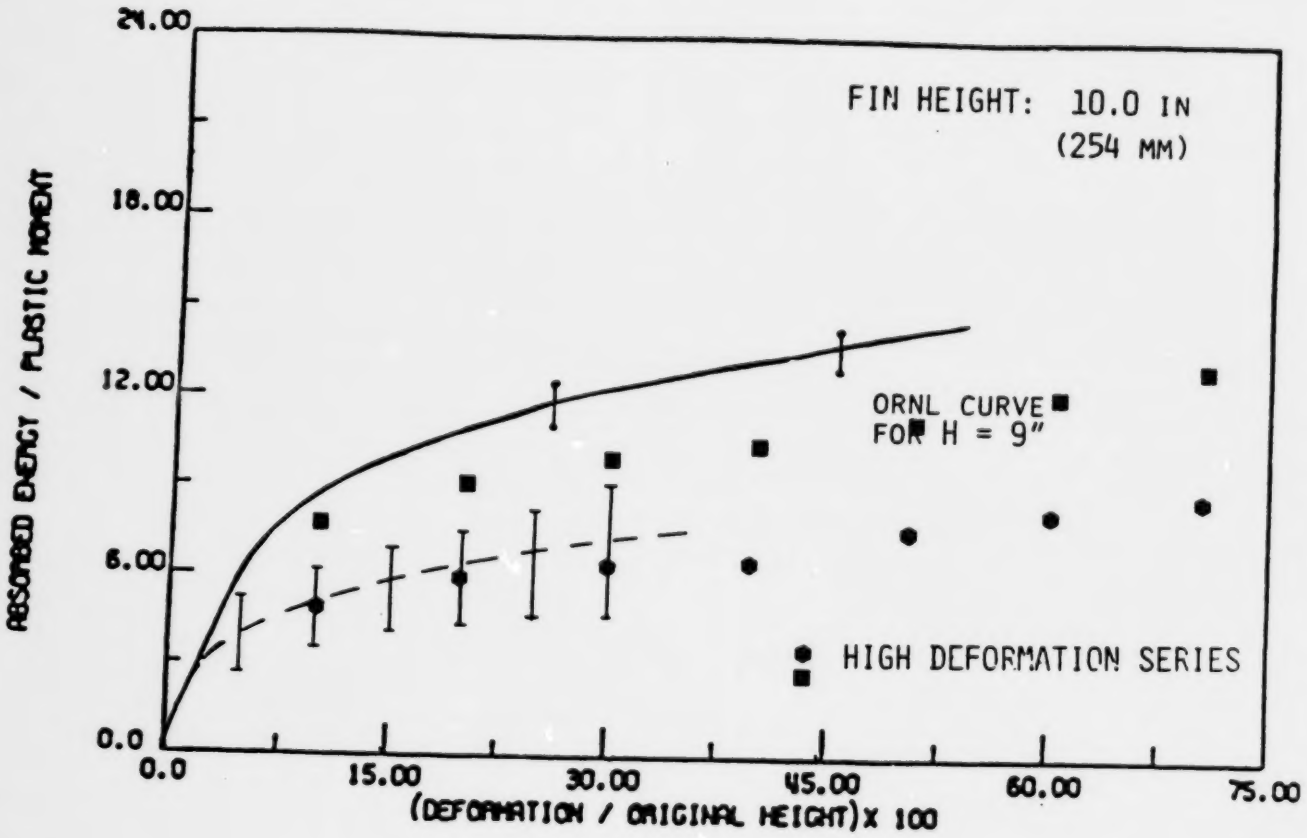
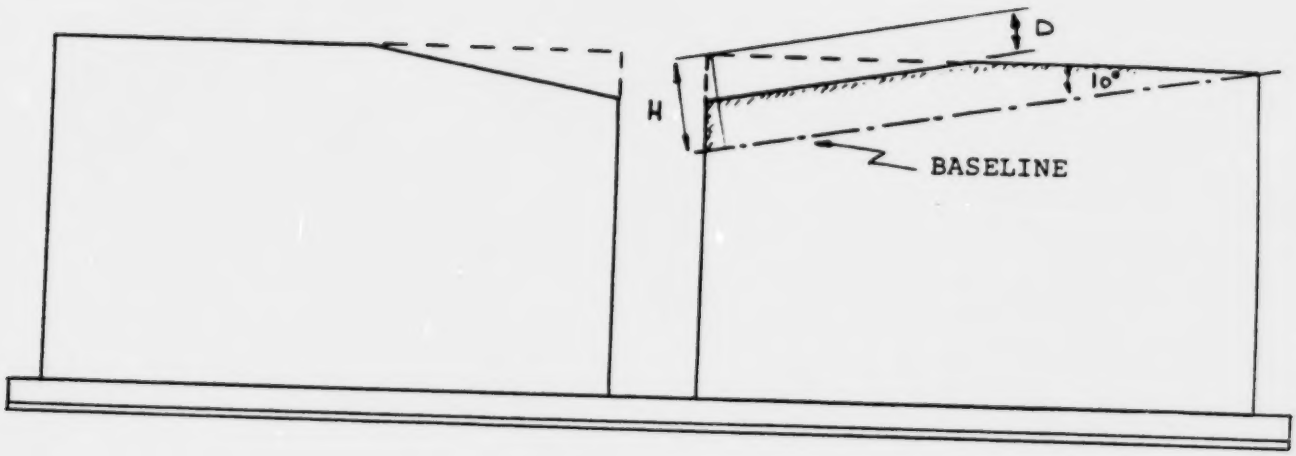
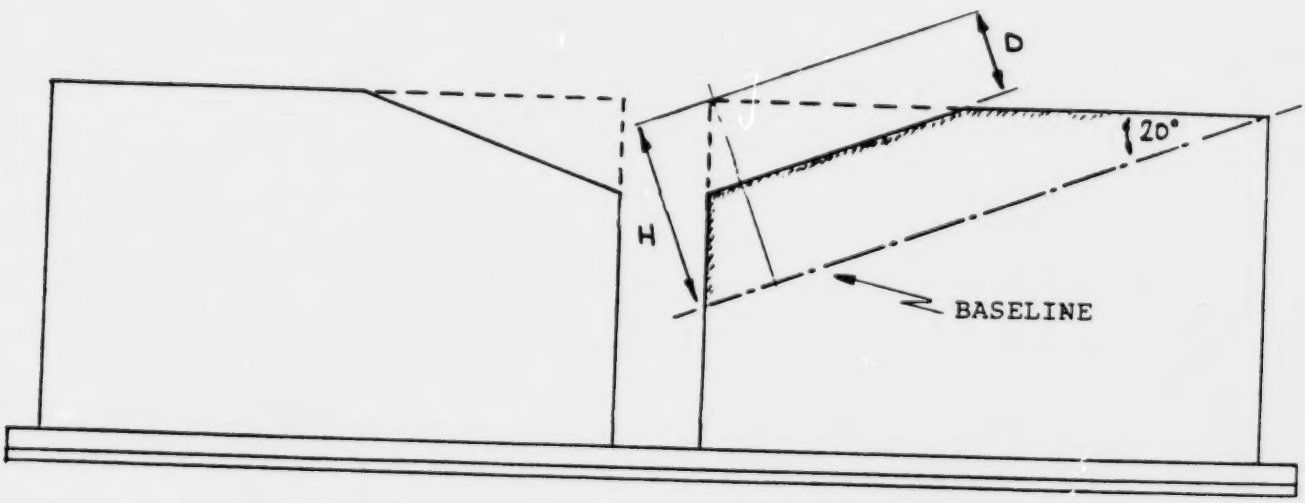


FIGURE 19

The Absorbed Energy Derived From Load Cell Test Data Divided by the Plastic Moment as a Function of the Percentage of Deformation Experienced by Impacted Specimens With a ZERO-Degree Angle of Inclination.

FIGURE 20





$$\text{PER CENT DEFORMATION} = \frac{D}{H} \times 100$$

SCHEME FOR CALCULATING PERCENT DEFORMATION IN NON-SQUARE IMPACT TESTS

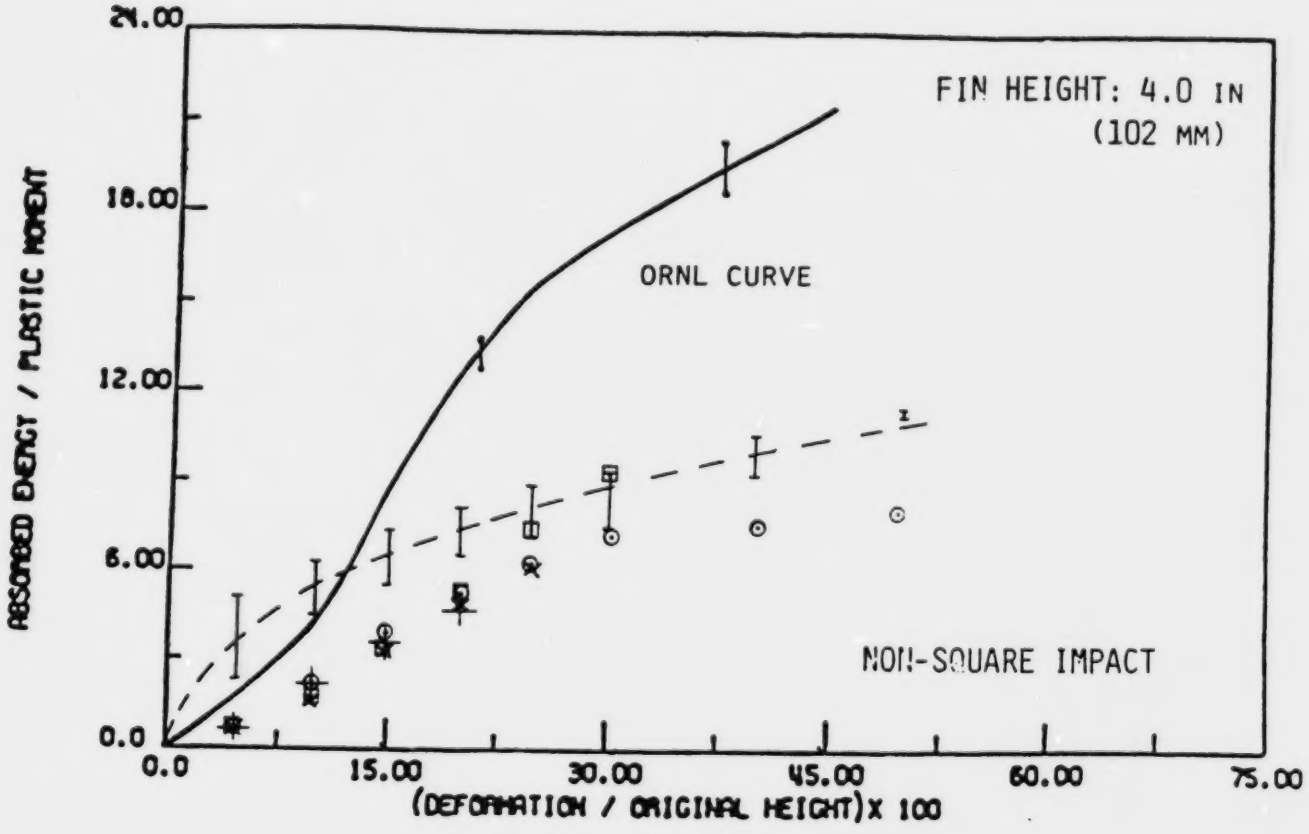


FIGURE 21

The Absorbed Energy Derived From Load Cell Test Data Divided by the Plastic Moment as a Function of the Percentage of Deformation Experienced by Impacted Specimens With a ZERO-Degree Angle of Inclination.

+ 0.25" Thick, 10° Hammer Face
× 0.375"Thick, 10° Hammer Face
⊙ 0.25" Thick, 20° Hammer Face
⊡ 0.375"Thick, 20° Hammer Face

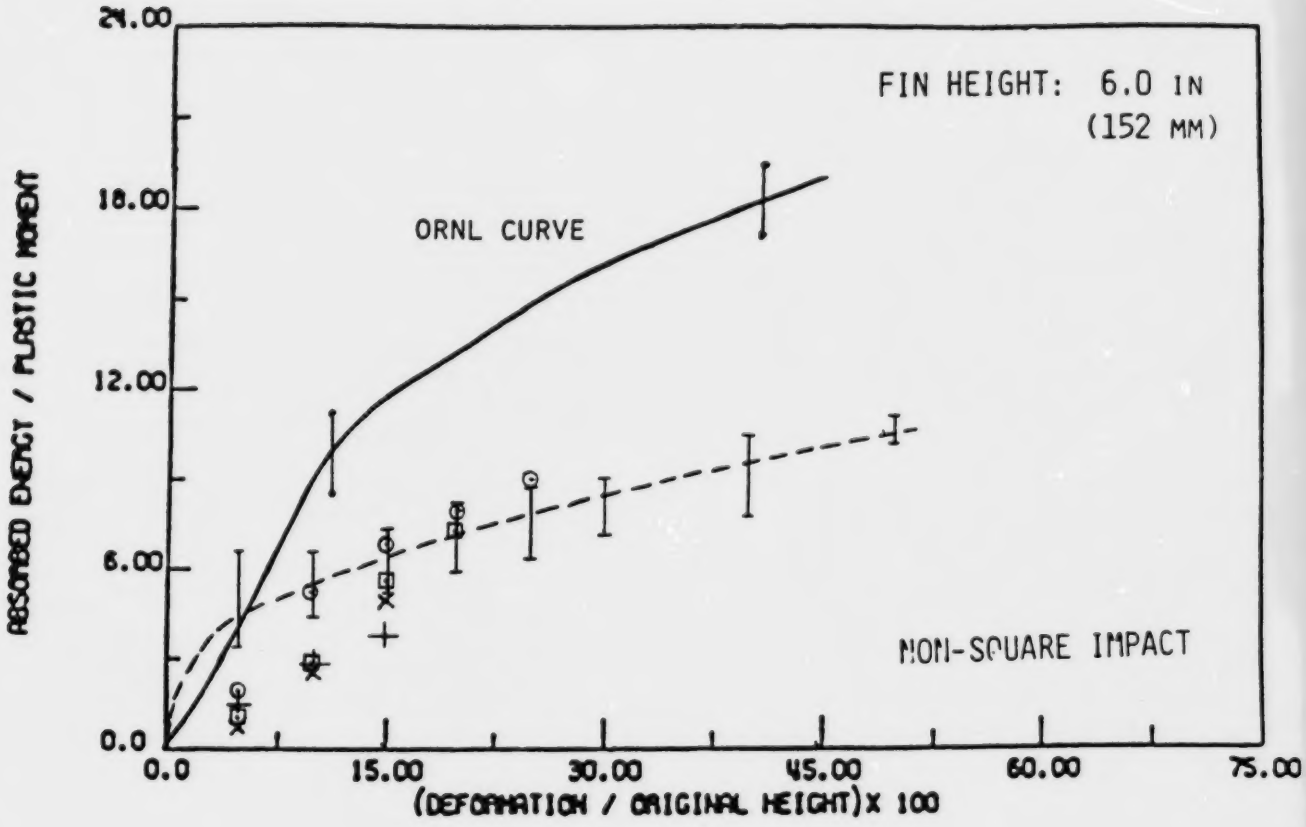


FIGURE 22

The Absorbed Energy Derived From Load Cell Test Data Divided by the Plastic Moment as a Function of the Percentage of Deformation Experienced by Impacted Specimens With a ZERO-Degree Angle of Inclination.

+ 0.25" Thick, 10° Hammer Face
× 0.375"Thick, 10° Hammer Face
⊙ 0.25" Thick, 20° Hammer Face
⊡ 0.375"Thick, 20° Hammer Face

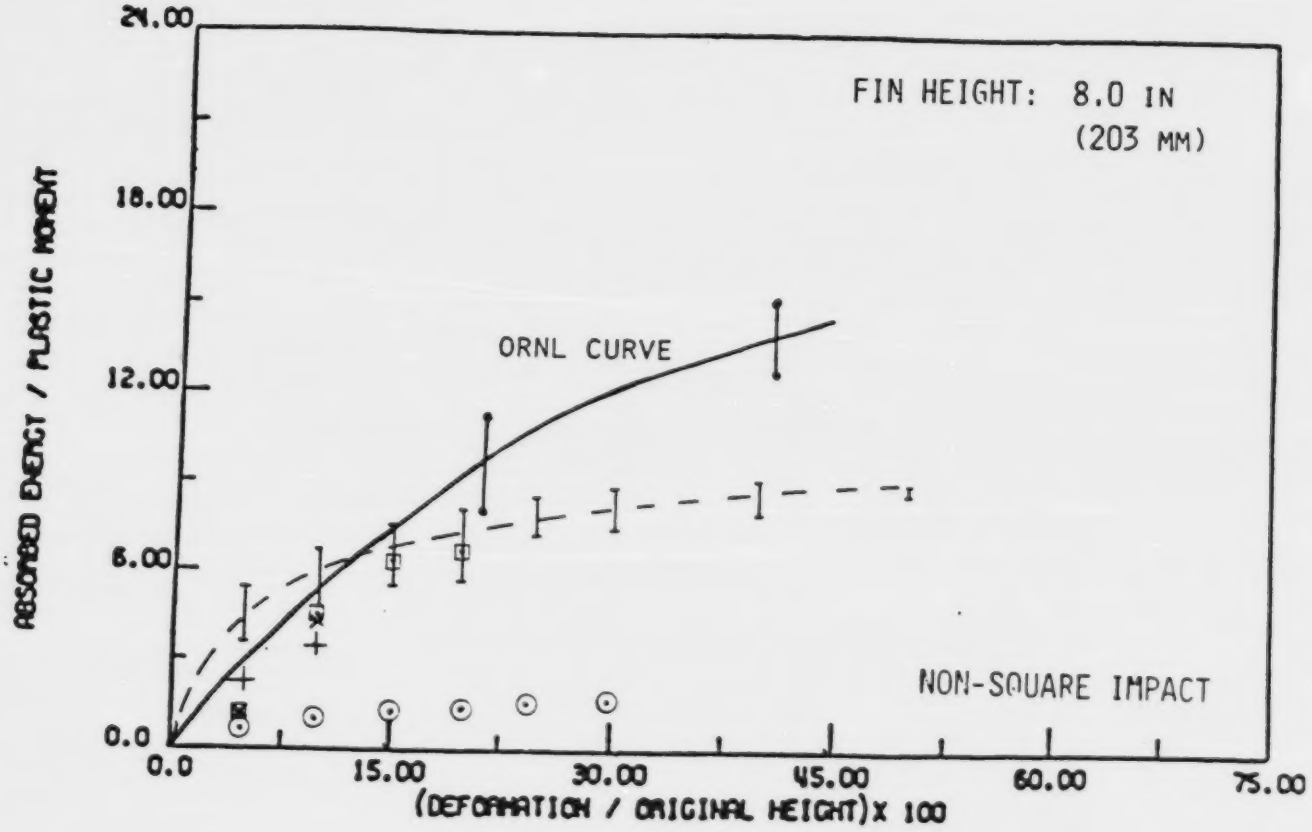


FIGURE 23

The Absorbed Energy Derived From Load Cell Test Data Divided by the Plastic Moment as a Function of the Percentage of Deformation Experienced by Impacted Specimens With a ZERO-Degree Angle of Inclination.

+ 0.25" Thick, 10° Hammer Face
× 0.375"Thick, 10° Hammer Face
⊙ 0.25" Thick, 20° Hammer Face
⊡ 0.375"Thick, 20° Hammer Face

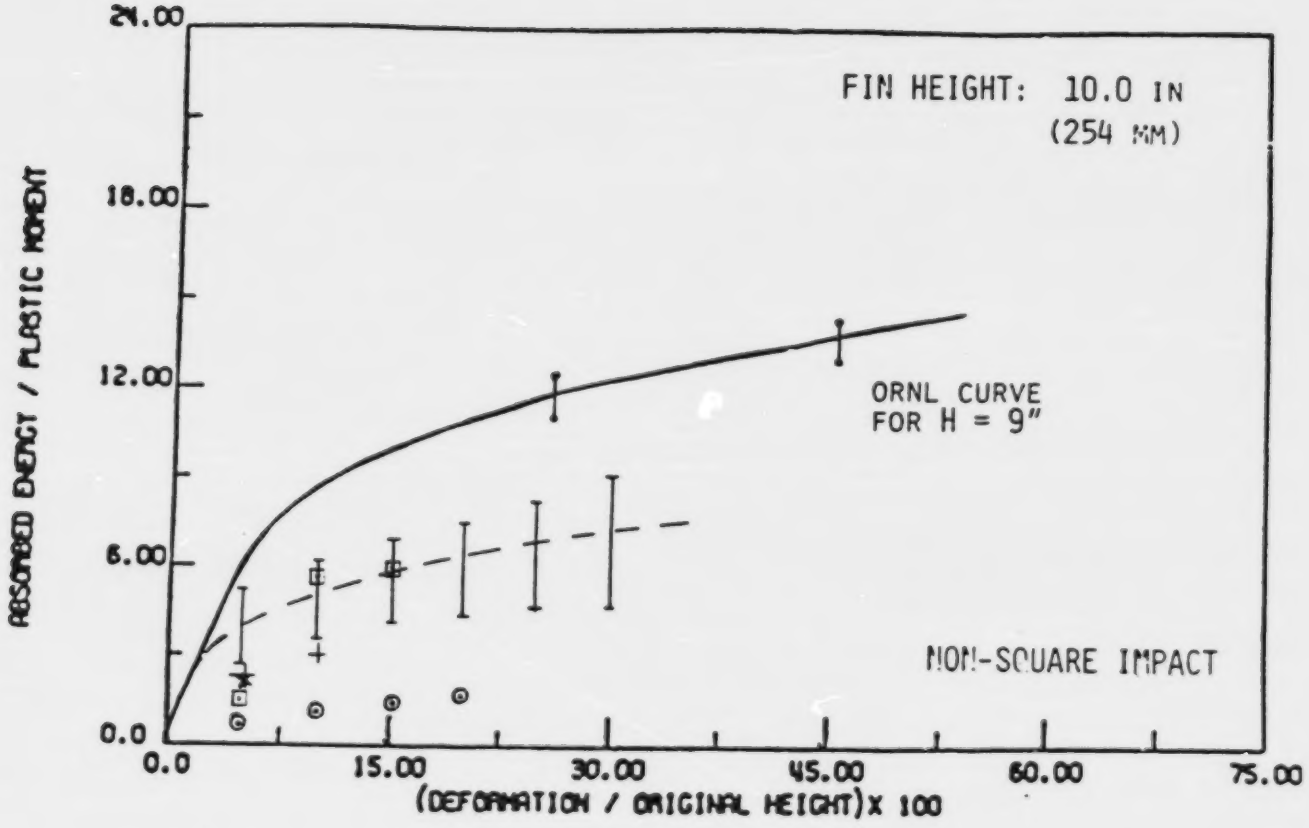


FIGURE 24

The Absorbed Energy Derived From Load Cell Test Data Divided by the Plastic Moment as a Function of the Percentage of Deformation Experienced by Impacted Specimens With a ZERO-Degree Angle of Inclination.

+ 0.25" Thick, 10° Hammer Face
× 0.375"Thick, 10° Hammer Face
⊙ 0.25" Thick, 20° Hammer Face
⊡ 0.375"Thick, 20° Hammer Face

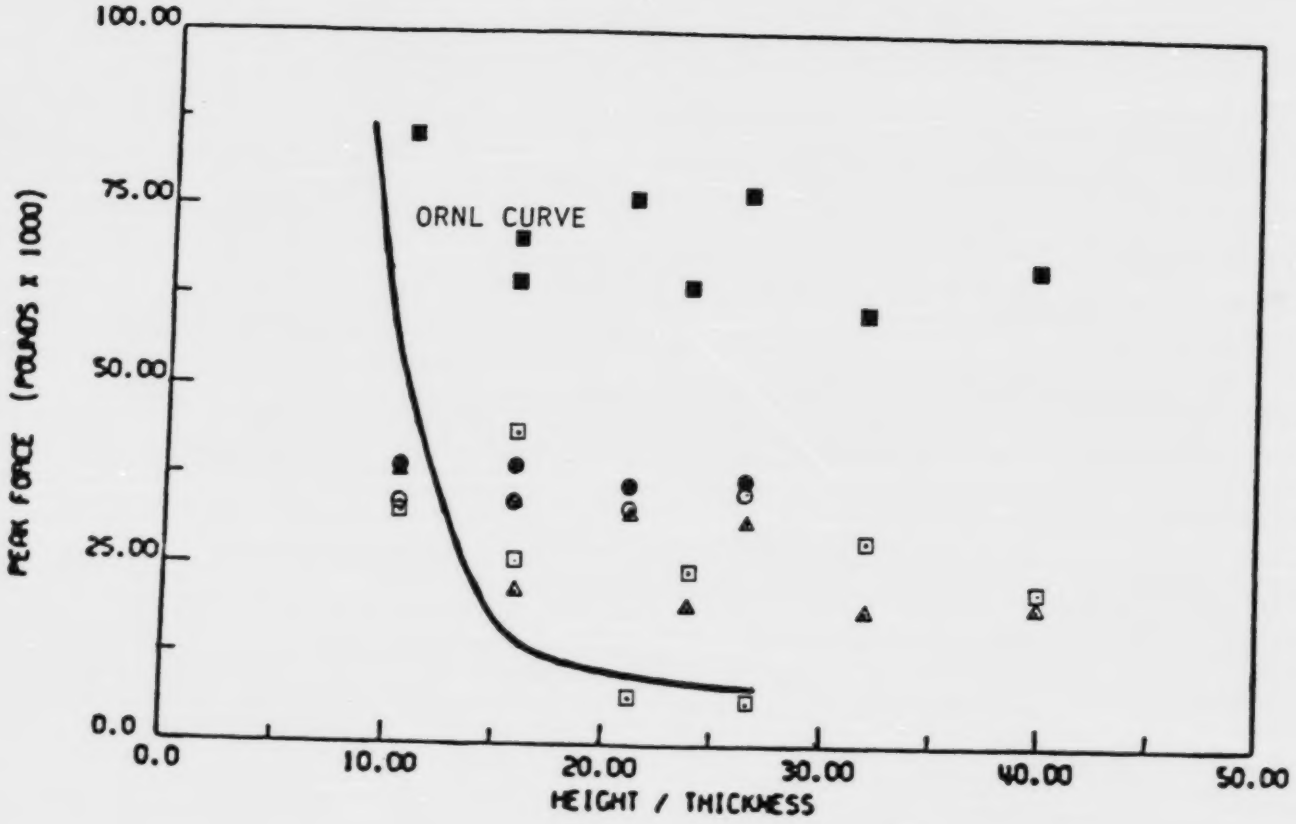


FIGURE 25

The Peak Force Derived From Load Cell Test Data as a Function of Specimen Height Divided by Thickness for Impact Specimens With a ZERO-Degree Angle of Inclination.

●	TYPE 7 - 44 ft/s
⊙	TYPE 7 22 ft/s
▲	TYPE 8
⊡	TYPE 9 - 10° Face
■	TYPE 9 20° Face

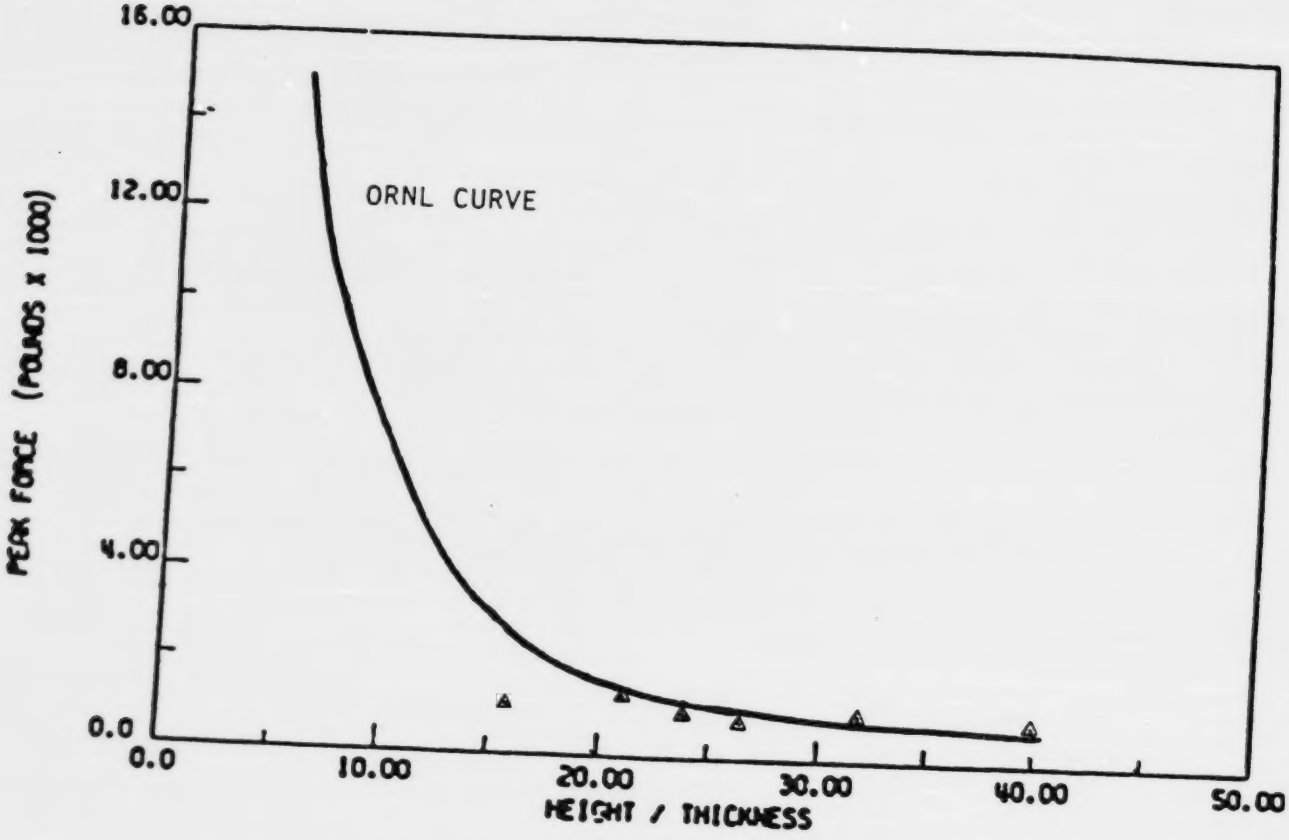


FIGURE 26

The Peak Force Derived From Load Cell Test Data as a Function of Specimen Height Divided by Thickness for Impact Specimens With a THIRTY-Degree Angle of Inclination.

TABLES OF RESULTS FOR IMPACT VELOCITY TESTS

OAK RIDGE FINS (Series 2): 0.375 inches THICK, 4.0 inches HIGH, 2.0 inches WIDE, 0.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	PERCENT DEFORMATION (%) FROM LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) LOADCELL	THEORY	ACCELRMTR
73411	90.25	367.	33122.	32706.	10800.	35975.	42.0	46.5	12.051	12.204	3.979
73412	90.25	367.	33122.	32675.	2039.	35975.	43.0	47.5	12.039	12.204	0.751
73413	- - -

OAK RIDGE FINS (Series 2): 0.375 inches THICK, 4.0 inches HIGH, 2.0 inches WIDE, 0.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	PERCENT DEFORMATION (%) FROM LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) THEORY	(PEAK ENERGY ABS)/(PLASTIC MOMENT) ACCELRMTR
73441	360.00	90.	32400.	31169.	0.	39432.	37.3	44.8	11.485	11.938	0.000
73442	360.00	90.	32400.	31686.	9968.	35854.	41.0	46.3	11.675	11.938	3.673
73443	360.00	90.	32400.	31116.	25416.	44675.	37.3	40.8	11.465	11.938	9.365
73444	360.00	90.	32400.	31583.	0.	40748.	41.0	44.6	11.637	11.938	0.000
73445	NO TRACE										
73446	360.00	90.	32400.	31512.	27048.	38500.	39.0	43.8	11.611	11.938	9.966
73447	360.00	90.	32400.	31596.	5138.	36230.	42.0	43.0	11.642	11.938	1.893

OAK RIDGE FINS (Series 2): 0.375 inches THICK, 6.0 inches HIGH, 2.0 inches WIDE, 0.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED (in-lbs) BY FIN FROM LOADCELL	PEAK ENERGY ABSORBED (in-lbs) FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	PERCENT DEFORMATION (%) FROM LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) THEORY	(PEAK ENERGY ABS)/(PLASTIC MOMENT) ACCELRMTR
73611	90.25	287.	25902.	25056.	5104.	33761.	39.0	36.6	9.232	9.544	1.880
73612	90.25	287.	25902.	25623.	10030.	31547.	39.7	35.1	9.441	9.544	3.696
73613	90.25	287.	25902.	25609.	0.	35422.	38.3	39.3	9.436	9.544	0.000
73614	90.25	287.	25902.	25585.	13323.	33761.	37.7	37.1	9.427	9.544	4.909
73615	90.25	287.	25902.	25486.	9288.	39849.	16.2	18.5	9.390	9.544	3.422
73616	90.25	287.	25902.	25490.	8860.	35975.	23.3	28.5	9.392	9.544	3.265
73617	90.25	287.	25902.	25590.	5492.	33761.	38.3	38.4	9.429	9.544	2.024

OAK RIDGE FINS (Series 2): 0.375 inches THICK, 6.0 inches HIGH, 2.0 inches WIDE, 0.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED (in-lbs) BY FIN FROM LOADCELL	PEAK ENERGY ABSORBED (in-lbs) FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	PERCENT DEFORMATION (%) FROM LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) THEORY	(PEAK ENERGY ABS)/(PLASTIC MOMENT) ACCELRMTR
73621	125.00	207.	25875.	25442.	9067.	38742.	34.5	34.2	9.375	9.534	3.341
73622	125.00	207.	25875.	25454.	8896.	37636.	33.8	33.9	9.379	9.534	3.278
73623	125.00	207.	25875.	25459.	10249.	38742.	35.2	33.7	9.381	9.534	3.776
73624	125.00	207.	25875.	25487.	11443.	34315.	36.5	32.4	9.391	9.534	4.216
73625	125.00	207.	25875.	25477.	13476.	37636.	35.2	34.2	9.387	9.534	4.965
73626	125.00	207.	25875.	25451.	15316.	40956.	35.2	34.0	9.378	9.534	5.643
73627	125.00	207.	25875.	25523.	10545.	33761.	38.3	38.9	9.404	9.534	3.885

OAK RIDGE FINS (Series 2): 0.375 inches THICK, 6.0 inches HIGH, 2.0 inches WIDE, 0.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED (in-lbs) BY FIN FROM LOADCELL	PEAK ENERGY ABSORBED (in-lbs) FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	PERCENT DEFORMATION (%) FROM LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) THEORY	(PEAK ENERGY ABS)/(PLASTIC MOMENT) ACCELRMTR
73631	204.00	127.	25908.	25395.	10277.	37082.	28.5	37.5	9.357	9.546	3.787
73632	204.00	127.	25908.	25248.	11746.	43170.	21.3	25.0	9.303	9.546	4.328
73633	204.00	127.	25908.	25281.	10235.	39849.	20.0	24.7	9.315	9.546	3.771
73634	204.00	127.	25908.	25201.	0.	44277.	18.7	21.2	9.286	9.546	0.000
73635	204.00	127.	25908.	25305.	4638.	38742.	26.7	30.6	9.324	9.546	1.709
73636	204.00	127.	25908.	25342.	9646.	37082.	28.5	35.0	9.338	9.546	3.554
73637	204.00	127.	25908.	25445.	9353.	36529.	33.2	37.9	9.376	9.546	3.446

OAK RIDGE FINS (Series 2): 0.375 inches THICK, 6.0 inches HIGH, 2.0 inches WIDE, 0.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED (in-lbs) BY FIN FROM LOADCELL	PEAK ENERGY ABSORBED (in-lbs) FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	PERCENT DEFORMATION (%) FROM LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) THEORY	(PEAK ENERGY ABS)/(PLASTIC MOMENT) ACCELRMTR
73641	360.00	70.	25200.	24326.	17428.	36844.	22.7	21.5	8.963	9.285	6.422
73642	360.00	70.	25200.	24257.	20344.	39354.	27.2	23.1	8.938	9.285	7.496
73643	360.00	70.	25200.	24193.	15387.	40990.	19.3	17.5	8.914	9.285	5.669
73644	360.00	70.	25200.	24184.	21959.	43544.	27.2	21.9	8.911	9.285	8.091
73645	360.00	70.	25200.	24259.	0.	41257.	25.3	21.1	8.939	9.285	0.000
73646	NO TRACE										
73647	360.00	70.	25200.	24509.	5222.	32043.	33.2	30.9	9.031	9.285	1.924

OAK RIDGE FINS (Series 2): 0.375 inches THICK, 8.0 inches HIGH, 2.0 inches WIDE, 0.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED (in-lbs) BY FIN FROM LOADCELL	PEAK ENERGY ABSORBED (in-lbs) FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	PERCENT DEFORMATION (%) FROM LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) THEORY	(PEAK ENERGY ABS)/(PLASTIC MOMENT) ACCELRMTR
73811	87.50	247.	21613.	21297.	9581.	33208.	34.1	36.4	7.847	7.9631	3.530
73812	87.50	247.	21613.	21320.	4551.	33208.	35.1	33.4	7.855	7.9631	1.677
73813	87.50	247.	21613.	21244.	10885.	34315.	31.1	34.4	7.828	7.9631	4.011
73814	NO TRACE										
73815	87.50	247.	21613.	21147.	6986.	34315.	30.1	35.7	7.792	7.9631	2.574
73816	87.50	247.	21613.	21101.	5799.	33208.	32.1	38.1	7.775	7.9631	2.137
73817	87.50	247.	21613.	21337.	8453.	34868.	28.8	29.0	7.862	7.9631	3.115

OAK RIDGE FINS (Series 2): 0.375 inches THICK, 8.0 inches HIGH, 2.0 inches WIDE, 0.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED (in-lbs) BY FIN FROM LOADCELL	PEAK ENERGY ABSORBED (in-lbs) FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	PERCENT DEFORMATION (%) FROM LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) THEORY	(PEAK ENERGY ABS)/(PLASTIC MOMENT) ACCELRMTR
73821	129.30	167.	21593.	21201.	11035.	37082.	27.2	27.8	7.812	7.9561	4.066
73822	NO TRACE										
73823	129.30	167.	21593.	21173.	6103.	35422.	15.4	19.5	7.801	7.9561	2.249
73824	129.30	167.	21593.	21161.	14412.	33208.	21.4	25.7	7.797	7.9561	5.310
73825	129.30	167.	21593.	21136.	7034.	38742.	20.4	22.7	7.788	7.9561	2.592
73826	129.30	167.	21593.	21176.	0.	35975.	22.3	26.1	7.803	7.9561	0.000
73827	129.00	167.	21543.	21173.	5639.	33208.	22.3	27.0	7.802	7.9381	2.078

OAK RIDGE FINS (Series 2): 0.375 inches THICK, 8.0 inches HIGH, 2.0 inches WIDE, 0.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED (in-lbs) BY FIN FROM LOADCELL	PEAK ENERGY ABSORBED (in-lbs) FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	PERCENT DEFORMATION (%) FROM LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) THEORY	(PEAK ENERGY ABS)/(PLASTIC MOMENT) ACCELRMTR
73831	216.00	100.	21600.	20878.	9000.	36529.	26.2	28.8	7.693	7.9391	3.316
73832	216.00	100.	21600.	20769.	11656.	40956.	21.4	23.0	7.653	7.9391	4.295
73833	216.00	100.	21600.	21072.	3761.	37636.	30.1	26.8	7.764	7.9391	1.386
73834	216.00	100.	21600.	20550.	6280.	37082.	19.4	19.1	7.572	7.9391	2.314
73835	216.00	100.	21600.	20810.	12551.	36529.	13.5	15.0	7.668	7.9391	4.625
73836	216.00	100.	21600.	20615.	16815.	37636.	14.0	16.2	7.596	7.9391	6.196
73837	216.00	100.	21600.	20405.	9829.	34315.	24.8	23.0	7.518	7.9391	3.622

OAK RIDGE FINS (Series 2): 0.375 inches THICK, 8.0 inches HIGH, 2.0 inches WIDE, 0.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED (in-lbs) BY FIN FROM LOADCELL	PEAK ENERGY ABSORBED (in-lbs) FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	PERCENT DEFORMATION (%) FROM LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) THEORY	(PEAK ENERGY ABS)/(PLASTIC MOMENT) ACCELRMTR
73841	- - - - - - - - - - - - - - - - - - - -			NO TRACE							
73842	360.00	60.	21600.	20548.	18121.	37636.	8.5	8.9	7.571	7.959	6.677
73843	360.00	60.	21600.	20765.	12725.	37636.	13.0	13.2	7.651	7.959	4.688
73844	360.00	60.	21600.	20533.	10399.	37082.	9.0	8.8	7.566	7.959	3.832
73845	360.00	60.	21600.	20620.	17519.	38189.	12.5	11.5	7.598	7.959	6.455
73846	360.00	60.	21600.	20646.	0.	37636.	11.0	11.1	7.607	7.959	0.000
73847	360.00	60.	21600.	20785.	3373.	34315.	13.0	16.3	7.658	7.959	1.243

OAK RIDGE FINS (Series 2): 0.375 inches THICK, 10.0 inches HIGH, 2.0 inches WIDE, 0.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	PERCENT DEFORMATION (%) FROM LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) THEORY	(PEAK ENERGY ABS)/(PLASTIC MOMENT) ACCELRMTR
73111	87.50	247.	21613.	20217.	7744.	36529.	25.6	19.9	7.449	7.963	2.853
73112	NO TRACE										
73113	87.50	247.	21613.	21338.	11634.	32654.	33.9	27.2	7.862	7.963	4.287
73114	87.50	247.	21613.	21320.	5624.	37082.	33.1	25.0	7.856	7.963	2.072
73115	87.50	247.	21613.	21267.	7546.	38189.	28.8	33.2	7.836	7.963	2.780
73116	87.50	247.	21613.	21242.	8419.	34868.	23.7	26.4	7.827	7.963	3.102
73117	87.50	247.	21613.	21326.	8453.	33208.	23.7	26.9	7.858	7.963	3.115

OAK RIDGE FINS (Series 2): 0.375 inches THICK, 10.0 inches HIGH, 2.0 inches WIDE, 0.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	PERCENT DEFORMATION (%) FROM LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) THEORY	(PEAK ENERGY ABS)/(PLASTIC MOMENT) ACCELRMTR
73121	129.30	167.	21593.	21182.	9055.	37636.	25.6	29.6	7.805	7.956	3.336
73122	129.30	167.	21593.	21127.	14929.	37082.	16.6	18.1	7.784	7.956	5.501
73123	129.00	167.	21543.	21167.	10209.	33761.	22.9	24.1	7.799	7.938	3.761
73124	129.30	167.	21593.	21154.	8107.	37636.	12.6	16.0	7.794	7.956	2.987
73125	129.30	167.	21593.	21213.	3265.	39296.	25.6	28.1	7.816	7.956	1.203
73126	NO TRACE										
73127	129.30	167.	21593.	21220.	308.	40956.	26.0	27.6	7.819	7.956	0.113

OAK RIDGE FINS (Series 2): 0.375 inches THICK, 10.0 inches HIGH, 2.0 inches WIDE, 0.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	PERCENT DEFORMATION (%) FROM LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) THEORY	(PEAK ENERGY ABS)/(PLASTIC MOMENT) ACCELRMTR
73131	216.00	100.	21600.	20900.	11334.	38742.	19.3	13.9	7.701	7.959	4.176
73132	216.00	100.	21600.	20930.	8780.	38742.	20.1	18.6	7.712	7.959	3.235
73133	NO TRACE										
73134	216.00	100.	21600.	20867.	13673.	38189.	17.0	15.6	7.689	7.959	5.038
73135	216.00	100.	21600.	20941.	11663.	39296.	16.6	14.2	7.716	7.959	4.298
73136	216.00	100.	21600.	20768.	0.	43724.	6.7	6.2	7.652	7.959	0.000
73137	216.00	100.	21600.	20955.	15880.	34324.	19.3	14.9	7.721	7.959	5.851

OAK RIDGE FINS (Series 2): 0.375 inches THICK, 10.0 inches HIGH, 2.0 inches WIDE, 0.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED (in-lbs) BY FIN FROM LOADCELL	PEAK ENERGY ABSORBED (in-lbs) FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	PERCENT DEFORMATION (%) FROM LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) THEORY	(PEAK ENERGY ABS)/(PLASTIC MOMENT) ACCELRMTR
73141	360.00	60.	21600.	20587.	16083.	37636.	10.7	7.9	7.585	7.9591	5.926
73142	360.00	60.	21600.	20712.	11975.	37912.	15.4	12.2	7.632	7.9591	4.412
73143	360.00	60.	21600.	20692.	0.	39849.	12.6	11.1	7.624	7.9591	0.000
73144	360.00	60.	21600.	20253.	0.	41310.	4.0	4.0	7.462	7.9591	0.000
73145	360.00	60.	21600.	20428.	16559.	35975.	7.1	5.9	7.527	7.9591	6.101
73146	360.00	60.	21600.	20398.	11412.	35422.	7.1	6.2	7.516	7.9591	4.205
73147	360.00	60.	21600.	20701.	17577.	33761.	11.9	12.4	7.627	7.9591	6.476

OAK RIDGE FINS (Series 2): 0.375 inches THICK, 4.0 inches HIGH, 2.0 inches WIDE, 0.0 degrees INCLINATION

FIN ID NUMBER	ABSORBED ENERGY/(PLASTIC MOMENT) AS A FUNCTION OF PERCENT FIN DEFORMATION (LOAD CELL DATA) 5 %	10 %	15 %	20 %	25 %	30 %	40 %	50 %
73411	4.08	5.82	7.43	8.53	9.33	9.90	10.66	
73412	3.50	5.54	7.24	8.32	9.12	9.76	10.60	
73413	- - -

OAK RIDGE FINS (Series 2): 0.375 inches THICK, 4.0 inches HIGH, 2.0 inches WIDE, 0.0 degrees INCLINATION

FIN ID NUMBER	ABSORBED ENERGY/(PLASTIC MOMENT) AS A FUNCTION OF PERCENT FIN DEFORMATION (LOAD CELL DATA)							
	5 %	10 %	15 %	20 %	25 %	30 %	40 %	50 %
73441	3.31	7.64	8.15	9.19	9.83	10.60	10.85	
73442	3.77	7.01	7.27	8.07	9.27	9.42	10.10	
73443	3.93	7.77	8.19	9.37	9.87	10.71	11.05	
73444	3.76	7.34	7.75	8.67	9.61	10.12	10.73	
73445	- - -

OAK RIDGE FINS (Series 2): 0.375 inches THICK, 6.0 inches HIGH, 2.0 inches WIDE, 0.0 degrees INCLINATION

FIN ID NUMBER	ABSORBED ENERGY/(PLASTIC MOMENT) AS A FUNCTION OF PERCENT FIN DEFORMATION (LOAD CELL DATA)							
	5 %	10 %	15 %	20 %	25 %	30 %	40 %	50 %
73611	4.26	5.46	6.20	6.86	7.58	7.94		
73612	4.27	5.38	6.26	7.21	7.84	8.36		
73613	4.55	5.67	6.32	6.98	7.65	8.10	8.99	
73614	4.80	5.91	6.56	7.30	7.81	8.24	9.29	
73615	5.84	7.92	8.87					
73616	5.62	7.04	7.96	8.56	9.03			
73617	4.67	5.78	6.44	7.13	7.71	8.15	9.13	
AVERAGE	4.86	6.17	6.94	7.34	7.94	8.16	9.14	
STD DEV	0.63	0.95	1.04	0.62	0.54	0.16	0.15	

OAK RIDGE FINS (Series 2): 0.375 inches THICK, 6.0 inches HIGH, 2.0 inches WIDE, 0.0 degrees INCLINATION

FIN ID NUMBER	ABSORBED ENERGY/(PLASTIC MOMENT) AS A FUNCTION OF PERCENT FIN DEFORMATION (LOAD CELL DATA)							
	5 %	10 %	15 %	20 %	25 %	30 %	40 %	50 %
73621	5.48	6.41	7.20	7.72	8.26	8.62	9.21	
73622	5.40	6.43	7.20	7.69	8.27	8.59		
73623	5.36	6.39	7.14	7.66	8.22	8.56		
73624	4.97	5.94	6.78	7.57	8.02	8.59		
73625	5.25	6.22	6.98	7.56	8.01	8.44		
73626	5.43	6.36	7.10	7.67	8.04	8.45		
73627	4.80	5.80	6.58	7.17	7.75	8.19	9.28	
AVERAGE	5.24	6.22	7.00	7.57	8.08	8.49	9.24	
STD DEV	0.26	0.25	0.24	0.19	0.18	0.15	0.05	

OAK RIDGE FINS (Series 2): 0.375 inches THICK, 6.0 inches HIGH, 2.0 inches WIDE, 0.0 degrees INCLINATION

FIN ID NUMBER	ABSORBED ENERGY/(PLASTIC MOMENT) AS A FUNCTION OF PERCENT FIN DEFORMATION (LOAD CELL DATA)							
	5 %	10 %	15 %	20 %	25 %	30 %	40 %	50 %
73631	5.44	5.60	6.65	7.42	7.86	8.26	8.85	
73632	6.01	6.45	7.43	8.22	8.67			
73633	6.00	6.62	7.57	8.38	8.71			
73634	6.38	6.86	7.83	8.59	8.91			
73635	5.60	5.85	6.87	7.59	8.05	8.58		
73636	5.56	5.55	6.59	7.38	7.83	8.12	8.64	
73637	5.20	5.58	6.47	7.23	7.92	8.30	9.22	
AVERAGE	5.74	6.07	7.06	7.83	8.28	8.31	8.91	
STD DEV	0.40	0.56	0.54	0.55	0.47	0.19	0.29	

OAK RIDGE FINS (Series 2): 0.375 inches THICK, 6.0 inches HIGH, 2.0 inches WIDE, 0.0 degrees INCLINATION

FIN ID NUMBER	ABSORBED ENERGY/(PLASTIC MOMENT) AS A FUNCTION OF PERCENT FIN DEFORMATION (LOAD CELL DATA)							
	5 %	10 %	15 %	20 %	25 %	30 %	40 %	50 %
73641	5.76	6.69	7.77	8.15	8.33			
73642	5.91	6.61	7.76	7.93	8.13			
73643	5.49	7.11	7.88	8.23				
73644	5.97	6.69	7.84	8.07				
73645	6.10	6.73	7.82	8.21				
73646	- - -

OAK RIDGE FINS (Series 2): 0.375 inches THICK, 8.0 inches HIGH, 2.0 inches WIDE, 0.0 degrees INCLINATION

FIN ID NUMBER	ABSORBED ENERGY/(PLASTIC MOMENT) AS A FUNCTION OF PERCENT FIN DEFORMATION (LOAD CELL DATA)							
	5 %	10 %	15 %	20 %	25 %	30 %	40 %	50 %
73811	3.96	5.12	5.56	6.04	6.44	6.74	7.47	
73812	3.92	5.13	5.60	6.10	6.44	6.69	7.45	
73813	4.23	5.46	5.98	6.47	6.78	7.04	7.54	
73814					-NO TRACE			
73815	4.46	5.63	6.15	6.51	6.82	7.05	7.49	
73816	4.18	5.33	5.78	6.15	6.46	6.65	7.21	
73817	4.49	5.53	6.32	6.91	7.42			
AVERAGE	4.21	5.37	5.90	6.36	6.73	6.83	7.43	
STD DEV	0.24	0.21	0.30	0.33	0.38	0.20	0.13	

OAK RIDGE FINS (Series 2): 0.375 inches THICK, 8.0 inches HIGH, 2.0 inches WIDE, 0.0 degrees INCLINATION

FIN ID NUMBER	ABSORBED ENERGY/(PLASTIC MOMENT) AS A FUNCTION OF PERCENT FIN DEFORMATION (LOAD CELL DATA)							
	5 %	10 %	15 %	20 %	25 %	30 %	40 %	50 %
73821	4.52	5.30	6.20	6.62	6.96	7.21		
73822					-NO TRACE			
73823	5.09	6.53	7.17	7.63				
73824	5.02	5.93	6.49	6.95	7.27	7.53		
73825	5.07	5.95	6.52	6.99	7.31	7.54	7.55	
73826	4.87	5.85	6.38	6.82	7.19	7.46	7.60	
73827	4.82	5.96	6.59	7.08	7.53			
AVERAGE	4.90	5.92	6.56	7.01	7.25	7.43	7.57	
STD DEV	0.22	0.39	0.33	0.34	0.21	0.16	0.04	

OAK RIDGE FINS (Series 2): 0.375 inches THICK, 8.0 inches HIGH, 2.0 inches WIDE, 0.0 degrees INCLINATION

FIN ID NUMBER	ABSORBED ENERGY/(PLASTIC MOMENT) AS A FUNCTION OF PERCENT FIN DEFORMATION (LOAD CELL DATA)							
	5 %	10 %	15 %	20 %	25 %	30 %	40 %	50 %
73831	5.33	6.02	6.31	6.77	6.89	6.94		
73832	5.45	6.02	6.21	6.66	6.71			
73833	5.19	5.93	6.19	6.39	6.74	6.71		
73834	5.84	6.16	6.47	6.74				
73835	5.53	6.65	7.27					
73836	5.67	6.54	7.12					
73837	5.77	6.29	6.88	7.04	7.14			
AVERAGE	5.54	6.23	6.63	6.72	6.87	6.83		
STD DEV	0.24	0.28	0.45	0.23	0.20	0.17		

OAK RIDGE FINS (Series 2): 0.375 inches THICK, 8.0 inches HIGH, 2.0 inches WIDE, 0.0 degrees INCLINATION

FIN ID NUMBER	ABSORBED ENERGY/(PLASTIC MOMENT) AS A FUNCTION OF PERCENT FIN DEFORMATION (LOAD CELL DATA)							
	5 %	10 %	15 %	20 %	25 %	30 %	40 %	50 %
73841	-NO TRACE-							
73842	6.75							
73843	6.15	7.01	7.47					
73844	6.77							
73845	6.63	6.93	7.37					
73846	6.56	7.13						
73847	6.21	6.85	7.31					
AVERAGE	6.51	6.98	7.38					
STD DEV	0.27	0.12	0.08					

OAK RIDGE FINS (Series 2): 0.375 inches THICK, 10.0 inches HIGH, 2.0 inches WIDE, 0.0 degrees INCLINATION

FIN ID NUMBER	ABSORBED ENERGY/(PLASTIC MOMENT) AS A FUNCTION OF PERCENT FIN DEFORMATION (LOAD CELL DATA) 5 %	10 %	15 %	20 %	25 %	30 %	40 %	50 %
73111	5.24	6.02	6.68	7.21				
73112	-NO TRACE							
73113	4.45	5.43	6.12	6.70	7.22	7.77		
73114	4.74	5.69	6.34	6.97	7.51			
73115	5.03	5.75	6.24	6.66	7.01	7.23		
73116	5.38	6.04	6.60	6.96	7.28	7.59		
73117	5.17	6.08	6.70	7.22	7.64			
AVERAGE	5.00	5.84	6.45	6.95	7.33	7.53		
STD DEV	0.35	0.26	0.25	0.24	0.25	0.28		

OAK RIDGE FINS (Series 2): 0.375 inches THICK, 10.0 inches HIGH, 2.0 inches WIDE, 0.0 degrees INCLINATION

FIN ID NUMBER	ABSORBED ENERGY/(PLASTIC MOMENT) AS A FUNCTION OF PERCENT FIN DEFORMATION (LOAD CELL DATA) 5 %	10 %	15 %	20 %	25 %	30 %	40 %	50 %
73121	4.82	5.63	6.15	6.58	6.86	7.14		
73122	5.60	6.64	7.25					
73123	5.23	6.10	6.70	7.27	7.72			
73124	5.42	6.76	7.31					
73125	4.86	5.70	6.21	6.68	7.00	7.28		
73126	-NO TRACE							
73127	4.73	5.65	6.24	6.72	7.09	7.39		
AVERAGE	5.11	6.08	6.64	6.81	7.17	7.27		
STD DEV	0.36	0.51	0.53	0.31	0.38	0.12		

OAK RIDGE FINS (Series 2): 0.375 inches THICK, 10.0 inches HIGH, 2.0 inches WIDE, 0.0 degrees INCLINATION

FIN ID NUMBER	ABSORBED ENERGY/(PLASTIC MOMENT) AS A FUNCTION OF PERCENT FIN DEFORMATION (LOAD CELL DATA) 5 %	10 %	15 %	20 %	25 %	30 %	40 %	50 %
73131	5.98	6.90	7.37	7.58				
73132	5.98	7.01	7.23	7.35	7.47	7.56		
73133	-NO TRACE							
73134	5.99	6.77	7.04	7.26				
73135	5.97	6.98	7.46					
73136	7.29							
73137	6.03	7.16	7.59					
AVERAGE	6.21	6.96	7.34	7.39	7.47	7.56		
STD DEV	0.53	0.14	0.21	0.17				

OAK RIDGE FINS (Series 2): 0.375 inches THICK, 10.0 inches HIGH, 2.0 inches WIDE, 0.0 degrees INCLINATION

FIN ID NUMBER	ABSORBED ENERGY/(PLASTIC MOMENT) AS A FUNCTION OF PERCENT FIN DEFORMATION (LOAD CELL DATA)							
	5 %	10 %	15 %	20 %	25 %	30 %	40 %	50 %
73141	6.40	7.16						
73142	6.29	6.63	6.92					
73143	6.39	7.14	7.37					
73144					-NO TRACE			
73145	6.72							
73146	7.13							
73147	6.30	7.04	7.32					
AVERAGE	6.54	6.99	7.20					
STD DEV	0.33	0.25	0.25					

TABLES OF RESULTS FOR STAINLESS STEEL SPECIMENS

STAINLESS STEEL OAK RIDGE TYPE FINS: 0.250 inches THICK, 4.0 inches HIGH, 2.0 inches WIDE, 0.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	PERCENT DEFORMATION (%) FROM LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) THEORY	(PEAK ENERGY ABS)/(PLASTIC MOMENT) ACCELRMTR
82401	90.25	160.	14440.	13985.	11062.	21640.	47.0	37.7	11.333	11.702	8.964
82402	90.25	160.	14440.	13981.	12326.	21403.	44.0	37.0	11.330	11.702	9.988
82403	90.25	160.	14440.	14009.	7207.	20703.	45.0	36.4	11.353	11.702	5.840
82404	90.25	160.	14440.	14222.	13273.	20483.	45.0	37.2	11.525	11.702	10.756
82405	90.25	160.	14440.	13953.	9166.	21376.	42.0	35.0	11.307	11.702	7.428

STAINLESS STEEL OAK RIDGE TYPE FINS: 0.250 inches THICK, 6.0 inches HIGH, 2.0 inches WIDE, 0.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	PERCENT DEFORMATION (%) FROM LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) THEORY	(PEAK ENERGY ABS)/(PLASTIC MOMENT) ACCELRMTR
82601	NO TRACE										
82602	90.25	160.	14440.	14090.	10989.	18613.	45.0	35.2	11.418	11.702	8.905
82603	90.25	160.	14440.	14017.	11801.	20444.	41.0	31.3	11.359	11.702	9.563
82604	90.25	160.	14440.	14049.	11042.	21099.	45.0	35.2	11.385	11.702	8.948
82605	90.25	160.	14440.	14063.	11009.	19459.	47.7	34.9	11.396	11.702	8.921

STAINLESS STEEL OAK RIDGE TYPE FINS: 0.250 inches THICK, 8.0 inches HIGH, 2.0 inches WIDE, 0.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	PERCENT DEFORMATION (%) FROM LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) THEORY	(PEAK ENERGY ABS)/(PLASTIC MOMENT) ACCELRMTR
82801	90.25	160.	14440.	14176.	4599.	17585.	51.9	39.9	11.488	11.702	3.727
82802	90.25	160.	14440.	14115.	0.	18829.	65.1	42.4	11.439	11.702	0.000
82803	90.25	160.	14440.	14085.	8578.	20283.	44.0	32.3	11.414	11.702	6.951
82804	90.25	160.	14440.	14086.	11872.	19129.	55.3	34.7	11.415	11.702	9.620
82805	90.25	160.	14440.	14148.	11491.	18848.	76.9	57.9	11.465	11.702	9.312

STAINLESS STEEL OAK RIDGE TYPE FINS: 0.250 inches THICK, 10.0 inches HIGH, 2.0 inches WIDE, 0.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	PERCENT DEFORMATION (%) FROM LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) THEORY	(PEAK ENERGY ABS)/(PLASTIC MOMENT) ACCELRMTR
82101	90.25	207.	18682.	10627.	16130.	18833.	87.1	86.9	8.612	15.139	13.071
82102	90.25	167.	15072.	10102.	5684.	16651.	72.9	81.1	8.187	12.214	4.606
82103	90.25	147.	13267.	9458.	6117.	18938.	54.8	25.6	7.665	10.731	4.957
82104	90.25	160.	14440.	14073.	7080.	22072.	68.9	42.4	11.405	11.702	5.737
82105	90.25	160.	14440.	14136.	11227.	20310.	63.4	43.6	11.456	11.702	9.098
82106	90.25	160.	14440.	14125.	6468.	19390.	76.8	53.2	11.447	11.702	5.241
82107	90.25	160.	14440.	14082.	6268.	20924.	59.9	37.2	11.412	11.702	5.079

STAINLESS STEEL OAK RIDGE TYPE FINS: 0.375 inches THICK, 4.0 inches HIGH, 2.0 inches WIDE, 0.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	PERCENT DEFORMATION (%) FROM LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) THEORY	(PEAK ENERGY ABS)/(PLASTIC MOMENT) ACCELRMTR
83401	90.25	407.	36732.	36365.	0.	37967.	30.3	36.4	13.399	13.534	0.000
83402	90.25	447.	40342.	39906.	19089.	41848.	27.2	30.9	14.704	14.864	7.033
83403	90.25	447.	40342.	39972.	19968.	34644.	44.0	48.3	14.728	14.864	7.358
83404	90.25	447.	40342.	39954.	738.	39792.	39.0	44.0	14.721	14.864	0.272
83405	90.25	447.	40342.	39957.	13194.	40622.	38.0	45.4	14.722	14.864	4.861
83406	90.25	447.	40342.	39959.	19798.	40946.	39.0	45.0	14.723	14.864	7.295
83407	90.25	367.	33122.	32698.	10417.	38630.	22.3	25.9	12.048	12.204	3.838

STAINLESS STEEL OAK RIDGE TYPE FINS: 0.375 inches THICK, 6.0 inches HIGH, 2.0 inches WIDE, 0.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	PERCENT DEFORMATION (%) FROM LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) THEORY	(PEAK ENERGY ABS)/(PLASTIC MOMENT) ACCELRMTR
83601	90.25	407.	36732.	36488.	18992.	33766.	36.2	62.8	13.444	13.534	6.998
83602	90.25	407.	36732.	36441.	0.	35944.	39.7	44.9	13.427	13.534	0.000
83603	90.25	407.	36732.	36456.	20819.	35892.	47.0	51.9	13.433	13.534	7.671
83604	90.25	407.	36732.	36476.	19793.	33658.	62.7	72.9	13.440	13.534	7.293
83605	90.25	407.	36732.	35664.	14002.	33254.	58.2	74.6	13.141	13.534	5.159

STAINLESS STEEL OAK RIDGE TYPE FINS: 0.375 inches THICK, 8.0 inches HIGH, 2.0 inches WIDE, 0.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	PERCENT DEFORMATION (%) FROM LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) THEORY	(PEAK ENERGY ABS)/(PLASTIC MOMENT) ACCELRMTR
83801	90.25	367.	33122.	31703.	15323.	31908.	53.8	71.9	11.681	12.204	5.646
83802	90.25	367.	33122.	31722.	20548.	30973.	33.1	46.9	11.688	12.204	7.571
83803	90.25	367.	33122.	32886.	19432.	34315.	45.0	48.9	12.117	12.204	7.160
83804	90.25	367.	33122.	32811.	19299.	34496.	63.1	72.1	12.090	12.204	7.111
83805	90.25	367.	33122.	32203.	11445.	33278.	58.3	75.0	11.866	12.204	4.217

STAINLESS STEEL OAK RIDGE TYPE FINS: 0.375 inches THICK, 10.0 inches HIGH, 2.0 inches WIDE, 0.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	PERCENT DEFORMATION (%) FROM LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) THEORY	(PEAK ENERGY ABS)/(PLASTIC MOMENT) ACCELRMTR
83101	90.25	367.	33122.	32505.	24462.	30686.	56.0	62.9	11.977	12.204	9.013
83102	90.25	367.	33122.	32473.	16180.	35763.	51.2	59.7	11.965	12.204	5.962
83103	90.25	367.	33122.	30615.	17889.	27423.	65.8	73.8	11.281	12.204	6.591
83104	90.25	367.	33122.	27498.	9657.	28274.	70.9	81.4	10.132	12.204	3.558
83105	90.25	367.	33122.	31185.	17153.	36053.	52.0	61.6	11.490	12.204	6.320

STAINLESS STEEL OAK RIDGE TYPE FINS: 0.250 inches THICK, 4.0 inches HIGH, 2.0 inches WIDE, 30.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	PERCENT DEFORMATION (%) FROM LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) THEORY	(PEAK ENERGY ABS)/(PLASTIC MOMENT) ACCELRMTR
82431	22.50	100.	2250.	2237.	675.	928.	63.9	77.8	1.813	1.823	0.547
82432	22.50	100.	2250.	2232.	811.	878.	61.6	85.1	1.809	1.823	0.657
82433	22.50	100.	2250.	2227.	1562.	1446.	53.5	67.9	1.804	1.823	1.266
82434	22.50	100.	2250.	2229.	1186.	1126.	53.5	74.2	1.806	1.823	0.961
82435	22.50	100.	2250.	2224.	1037.	1186.	52.4	63.5	1.802	1.823	0.841

STAINLESS STEEL OAK RIDGE TYPE FINS: 0.250 inches THICK, 6.0 inches HIGH, 2.0 inches WIDE, 30.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	PERCENT DEFORMATION (%) FROM LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) THEORY	(PEAK ENERGY ABS)/(PLASTIC MOMENT) ACCELRMTR
82631	22.50	80.	1800.	1792.	335.	1066.	62.3	77.6	1.452	1.459	0.271
82632	22.50	80.	1800.	1794.	375.	816.	60.7	79.0	1.454	1.459	0.304
82633	22.50	80.	1800.	1786.	538.	749.	56.9	70.9	1.447	1.459	0.436
82634	22.50	80.	1800.	1793.	631.	816.	59.2	74.3	1.453	1.459	0.512
82635	22.50	80.	1800.	1791.	520.	716.	57.7	79.5	1.451	1.459	0.421

STAINLESS STEEL OAK RIDGE TYPE FINS: 0.250 inches THICK, 8.0 inches HIGH, 2.0 inches WIDE, 30.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	PERCENT DEFORMATION (%) FROM LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) THEORY	(PEAK ENERGY ABS)/(PLASTIC MOMENT) ACCELRMTR
82831	- - - - - - - - - - - - - - - - - - NO TRACE - - - - - - - - - - - - - - - - - -										
82832	22.50	60.	1350.	1257.	788.	816.	48.3	82.7	1.019	1.094	0.638
82833	22.50	60.	1350.	1291.	906.	933.	44.4	73.8	1.046	1.094	0.734
82834	22.50	60.	1350.	1310.	678.	816.	41.0	67.4	1.062	1.094	0.549
82835	22.50	60.	1350.	1291.	912.	933.	47.8	74.1	1.046	1.094	0.739

STAINLESS STEEL OAK RIDGE TYPE FINS: 0.250 inches THICK, 10.0 inches HIGH, 2.0 inches WIDE, 30.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	PERCENT DEFORMATION (%) FROM LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) THEORY	(PEAK ENERGY ABS)/(PLASTIC MOMENT) ACCELRMTR
82131	22.50	60.	1350.	1312.	927.	766.	61.9	62.2	1.063	1.094	0.752
82132	22.50	60.	1350.	1318.	960.	716.	58.7	65.4	1.068	1.094	0.778
82133	22.50	60.	1350.	1296.	779.	916.	63.3	61.5	1.050	1.094	0.631
82134	22.50	60.	1350.	1312.	1062.	982.	59.6	60.1	1.063	1.094	0.860
82135	22.50	60.	1350.	1313.	809.	783.	53.7	67.9	1.064	1.094	0.655

STAINLESS STEEL OAK RIDGE TYPE FINS: 0.375 inches THICK, 4.0 inches HIGH, 2.0 inches WIDE, 30.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	PERCENT DEFORMATION (%) FROM LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) THEORY	(PEAK ENERGY ABS)/(PLASTIC MOMENT) ACCELRMTR
83431	NO TRACE										
83432	NO TRACE										
83433	NO TRACE										
83434	NO TRACE										
83435	90.25	100.	9025.	8201.	8893.	4566.	72.7	96.4	3.022	3.325	3.277
83436	90.25	60.	5415.	5299.	4881.	7660.	43.4	20.6	1.952	1.995	1.798
83437	90.25	60.	5415.	5394.	4912.	2248.	50.1	91.9	1.987	1.995	1.810

STAINLESS STEEL OAK RIDGE TYPE FINS: 0.375 inches THICK, 8.0 inches HIGH, 2.0 inches WIDE, 30.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	PERCENT DEFORMATION (%) FROM LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) THEORY	(PEAK ENERGY ABS)/(PLASTIC MOMENT) ACCELRMTR
83831	22.50	200.	4500.	4392.	1353.	15324.	65.9	6.5	1.618	1.658	0.498
83832	22.50	200.	4500.	4487.	557.	1435.	61.5	75.9	1.653	1.658	0.205
83833	22.50	200.	4500.	4486.	1645.	1606.	65.9	80.6	1.653	1.658	0.606
83834	22.50	200.	4500.	4476.	0.	1565.	63.8	76.4	1.649	1.658	0.000
83835	22.50	200.	4500.	4474.	1275.	1658.	67.7	79.0	1.648	1.658	0.470

STAINLESS STEEL OAK RIDGE TYPE FINS: 0.375 inches THICK, 10.0 inches HIGH, 2.0 inches WIDE, 30.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	PERCENT DEFORMATION (%) FROM LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) THEORY	(PEAK ENERGY ABS)/(PLASTIC MOMENT) ACCELRMTR
83131	22.50	200.	4500.	4473.	163.	1046.	76.9	89.1	1.648	1.658	0.060
83132	22.50	200.	4500.	4469.	362.	1255.	80.0	89.8	1.647	1.658	0.134
83133	22.50	200.	4500.	4477.	1922.	1008.	75.5	86.2	1.649	1.658	0.708
83134	22.50	200.	4500.	4477.	2915.	876.	76.0	89.0	1.650	1.658	1.074
83135	22.50	200.	4500.	4479.	628.	918.	73.7	87.6	1.650	1.658	0.231

STAINLESS STEEL OAK RIDGE TYPE FINS: 0.250 inches THICK, 4.0 inches HIGH, 2.0 inches WIDE, 0.0 degrees INCLINATION

FIN ID NUMBER	ABSORBED ENERGY/(PLASTIC MOMENT) AS A FUNCTION OF PERCENT FIN DEFORMATION (LOAD CELL DATA)							
	5 %	10 %	15 %	20 %	25 %	30 %	40 %	50 %
82401	4.36	5.38	7.04	7.28	8.17	8.66	10.47	
82402	3.49	5.42	6.51	7.20	8.19	8.43	10.49	
82403	4.24	5.25	6.69	7.17	8.29	8.95	10.62	
82404	4.49	5.38	7.01	7.35	8.43	8.82	11.02	
82405	4.15	5.43	6.90	7.31	8.24	8.99	10.79	
AVERAGE	4.15	5.37	6.83	7.26	8.26	8.77	10.68	
STD DEV	0.39	0.07	0.22	0.07	0.11	0.23	0.23	

STAINLESS STEEL OAK RIDGE TYPE FINS: 0.250 inches THICK, 6.0 inches HIGH, 2.0 inches WIDE, 0.0 degrees INCLINATION

FIN ID NUMBER	ABSORBED ENERGY/(PLASTIC MOMENT) AS A FUNCTION OF PERCENT FIN DEFORMATION (LOAD CELL DATA)							
	5 %	10 %	15 %	20 %	25 %	30 %	40 %	50 %
82601	- - -

STAINLESS STEEL OAK RIDGE TYPE FINS: 0.250 inches THICK, 10.0 inches HIGH, 2.0 inches WIDE, 0.0 degrees INCLINATION

FIN ID NUMBER	ABSORBED ENERGY/(PLASTIC MOMENT) AS A FUNCTION OF PERCENT FIN DEFORMATION (LOAD CELL DATA)							
	5 %	10 %	15 %	20 %	25 %	30 %	40 %	50 %
82101	3.81							
82102	3.11							
82103	4.70	5.47	5.60					
82104	4.93	5.74	6.65	6.98	7.38	7.54	7.63	8.01
82105	4.66	5.93	6.56	7.29	7.62	7.81	8.16	8.43
82106	4.38	5.20	6.21	6.45	6.89	6.98	7.94	8.50
82107	4.24	5.12	6.01	6.47	6.97	7.21	7.56	8.74
AVERAGE	4.26	5.49	6.21	6.80	7.21	7.39	7.82	8.42
STD DEV	0.63	0.35	0.43	0.41	0.34	0.37	0.28	0.30

STAINLESS STEEL OAK RIDGE TYPE FINS: 0.375 inches THICK, 4.0 inches HIGH, 2.0 inches WIDE, 0.0 degrees INCLINATION

FIN ID NUMBER	ABSORBED ENERGY/(PLASTIC MOMENT) AS A FUNCTION OF PERCENT FIN DEFORMATION (LOAD CELL DATA)							
	5 %	10 %	15 %	20 %	25 %	30 %	40 %	50 %
83401	3.59	6.54	8.73	10.27	11.56	12.46		
83402	3.97	7.64	10.00	11.71	13.19	14.37		
83403	3.34	5.85	7.91	9.23	10.23	10.80	11.80	
83404	3.45	6.52	8.77	10.30	11.51	12.24	13.34	
83405	3.25	6.78	9.19	10.80	11.93	12.58	13.66	
83406	3.59	6.82	9.12	10.74	11.76	12.44	13.51	
83407	4.08	6.82	8.92	10.59	11.77			
AVERAGE	3.61	6.71	8.95	10.52	11.71	12.48	13.08	
STD DEV	0.31	0.53	0.63	0.74	0.87	1.14	0.86	

STAINLESS STEEL OAK RIDGE TYPE FINS: 0.375 inches THICK, 6.0 inches HIGH, 2.0 inches WIDE, 0.0 degrees INCLINATION

FIN ID NUMBER	ABSORBED ENERGY/(PLASTIC MOMENT) AS A FUNCTION OF PERCENT FIN DEFORMATION (LOAD CELL DATA)							
	5 %	10 %	15 %	20 %	25 %	30 %	40 %	50 %
83601	4.43	5.64	6.41	7.11	7.50	7.84	8.88	10.62
83602	5.03	6.67	7.88	8.71	9.35	9.79	11.83	
83603	5.01	6.24	7.14	7.90	8.40	8.79	10.02	12.52
83604	4.72	6.05	6.96	7.35	7.64	7.87	8.22	8.90
83605	4.77	6.31	7.22	7.64	8.00	8.18	8.41	8.47
AVERAGE	4.79	6.18	7.12	7.74	8.18	8.49	9.47	10.13
STD DEV	0.25	0.38	0.53	0.62	0.74	0.82	1.49	1.85

STAINLESS STEEL OAK RIDGE TYPE FINS: 0.375 inches THICK, 8.0 inches HIGH, 2.0 inches WIDE, 0.0 degrees INCLINATION

FIN ID NUMBER	ABSORBED ENERGY/(PLASTIC MOMENT) AS A FUNCTION OF PERCENT FIN DEFORMATION (LOAD CELL DATA)							
	5 %	10 %	15 %	20 %	25 %	30 %	40 %	50 %
83801	4.36	5.30	6.13	6.80	7.02	7.20	7.39	7.42
83802	4.88	7.50	8.94	10.02	10.68	10.89	11.31	
83803	4.41	5.33	6.00	6.86	7.50	7.90	8.81	11.00
83804	4.59	5.63	6.55	7.04	7.32	7.54	7.88	8.32
83805	4.79	6.02	6.98	7.43	7.63	7.89	8.07	8.16
AVERAGE	4.61	5.95	6.92	7.63	8.03	8.28	8.69	8.73
STD DEV	0.23	0.91	1.19	1.36	1.50	1.48	1.55	1.57

STAINLESS STEEL OAK RIDGE TYPE FINS: 0.375 inches THICK, 10.0 inches HIGH, 2.0 inches WIDE, 0.0 degrees INCLINATION

FIN ID NUMBER	ABSORBED ENERGY/(PLASTIC MOMENT) AS A FUNCTION OF PERCENT FIN DEFORMATION (LOAD CELL DATA)							
	5 %	10 %	15 %	20 %	25 %	30 %	40 %	50 %
83101	3.37	4.53	5.33	5.70	6.25	6.55	6.76	7.59
83102	4.49	5.82	6.44	7.12	7.59	8.09	8.61	9.15
83103	3.47	4.72	5.43	5.84	6.18	6.11	6.29	6.34
83104	3.38	4.47	5.03	5.22	5.29	5.30	5.27	5.09
83105	4.10	5.11	5.79	6.13	6.58	6.94	7.38	8.08
AVERAGE	3.76	4.93	5.60	6.00	6.38	6.60	6.86	7.25
STD DEV	0.51	0.56	0.54	0.71	0.83	1.03	1.24	1.57

STAINLESS STEEL OAK RIDGE TYPE FINS: 0.250 inches THICK, 4.0 inches HIGH, 2.0 inches WIDE, 30.0 degrees INCLINATION

FIN ID NUMBER	ABSORBED ENERGY/(PLASTIC MOMENT) AS A FUNCTION OF PERCENT FIN DEFORMATION (LOAD CELL DATA)							
	5 %	10 %	15 %	20 %	25 %	30 %	40 %	50 %
82431	0.10	0.25	0.39	0.53	0.66	0.79	1.00	1.20
82432	0.12	0.27	0.40	0.53	0.66	0.77	0.98	1.18
82433	0.16	0.34	0.55	0.72	0.86	0.99	1.22	1.43
82434	0.11	0.29	0.47	0.66	0.80	0.93	1.15	1.35
82435	0.07	0.31	0.54	0.73	0.90	1.03	1.27	1.48
AVERAGE	0.11	0.29	0.47	0.63	0.78	0.90	1.12	1.33
STD DEV	0.03	0.04	0.07	0.10	0.11	0.12	0.13	0.14

STAINLESS STEEL OAK RIDGE TYPE FINS: 0.250 inches THICK, 6.0 inches HIGH, 2.0 inches WIDE, 30.0 degrees INCLINATION

FIN ID NUMBER	ABSORBED ENERGY/(PLASTIC MOMENT) AS A FUNCTION OF PERCENT FIN DEFORMATION (LOAD CELL DATA)							
	5 %	10 %	15 %	20 %	25 %	30 %	40 %	50 %
82631	0.07	0.14	0.23	0.36	0.46	0.52	0.68	0.82
82632	0.06	0.15	0.28	0.40	0.49	0.57	0.72	0.85
82633	0.05	0.20	0.35	0.51	0.59	0.68	0.82	0.93
82634	0.06	0.18	0.34	0.47	0.57	0.66	0.81	0.95
82635	0.07	0.19	0.35	0.46	0.55	0.64	0.78	0.88
AVERAGE	0.06	0.17	0.31	0.44	0.53	0.61	0.76	0.89
STD DEV	0.01	0.02	0.05	0.06	0.05	0.06	0.06	0.05

STAINLESS STEEL OAK RIDGE TYPE FINS: 0.250 inches THICK, 8.0 inches HIGH, 2.0 inches WIDE, 30.0 degrees INCLINATION

FIN ID NUMBER	ABSORBED ENERGY/(PLASTIC MOMENT) AS A FUNCTION OF PERCENT FIN DEFORMATION (LOAD CELL DATA)							
	5 %	10 %	15 %	20 %	25 %	30 %	40 %	50 %
82831	- - -

STAINLESS STEEL OAK RIDGE TYPE FINS: 0.250 inches THICK, 10.0 inches HIGH, 2.0 inches WIDE, 30.0 degrees INCLINATION

FIN ID NUMBER	ABSORBED ENERGY/(PLASTIC MOMENT) AS A FUNCTION OF PERCENT FIN DEFORMATION (LOAD CELL DATA)							
	5 %	10 %	15 %	20 %	25 %	30 %	40 %	50 %
82131	0.03	0.06	0.10	0.11	0.14	0.14	0.16	0.21
82132	0.03	0.06	0.08					
82133	0.05	0.09	0.12					
82134	0.05	0.09	0.13	0.14	0.15			
82135	0.08	0.16	0.23	0.26	0.30	0.34	0.40	0.44
AVERAGE	0.05	0.09	0.13	0.17	0.20	0.24	0.28	0.33
STD DEV	0.02	0.04	0.06	0.08	0.09	0.14	0.17	0.16

STAINLESS STEEL OAK RIDGE TYPE FINS: 0.375 inches THICK, 4.0 inches HIGH, 2.0 inches WIDE, 30.0 degrees INCLINATION

FIN ID NUMBER	ABSORBED ENERGY/(PLASTIC MOMENT) AS A FUNCTION OF PERCENT FIN DEFORMATION (LOAD CELL DATA)							
	5 %	10 %	15 %	20 %	25 %	30 %	40 %	50 %
83431	- -				-NO TRACE			
83432	- -				-NO TRACE			
83433	- -				-NO TRACE			
83434	- -				-NO TRACE			
83435	0.02	0.11	0.13	0.20	0.23	0.26	0.32	0.38
83436	0.22	0.87	1.13	1.58	1.92			
83437	0.11	0.24	0.29	0.42	0.48	0.59	0.74	0.88
AVERAGE	0.12	0.40	0.52	0.73	0.88	0.42	0.53	0.63
STD DEV	0.10	0.41	0.54	0.75	0.91	0.24	0.30	0.35

STAINLESS STEEL OAK RIDGE TYPE FINS: 0.375 inches THICK, 8.0 inches HIGH, 2.0 inches WIDE, 30.0 degrees INCLINATION

FIN ID NUMBER	ABSORBED ENERGY/(PLASTIC MOMENT) AS A FUNCTION OF PERCENT FIN DEFORMATION (LOAD CELL DATA)							
	5 %	10 %	15 %	20 %	25 %	30 %	40 %	50 %
83831	1.15							
83832	0.12	0.26	0.42	0.55	0.66	0.77	0.99	1.18
83833	0.13	0.27	0.43	0.55	0.65	0.76	0.96	1.14
83834	0.14	0.30	0.46	0.58	0.70	0.80	1.01	1.19
83835	0.07	0.20	0.35	0.49	0.60	0.71	0.92	1.12
AVERAGE	0.32	0.26	0.42	0.54	0.65	0.76	0.97	1.16
STD DEV	0.47	0.04	0.05	0.04	0.04	0.04	0.04	0.04

STAINLESS STEEL OAK RIDGE TYPE FINS: 0.375 inches THICK, 10.0 inches HIGH, 2.0 inches WIDE, 30.0 degrees INCLINATION

FIN ID NUMBER	ABSORBED ENERGY/(PLASTIC MOMENT) AS A FUNCTION OF PERCENT FIN DEFORMATION (LOAD CELL DATA)							
	5 %	10 %	15 %	20 %	25 %	30 %	40 %	50 %
83131	0.08	0.19	0.31	0.40	0.49	0.56	0.72	0.86
83132	0.06	0.18	0.31	0.42	0.52	0.61	0.76	0.90
83133	0.05	0.16	0.30	0.42	0.54	0.63	0.80	0.95
83134	0.10	0.21	0.35	0.48	0.59	0.68	0.83	0.97
83135	0.10	0.20	0.34	0.46	0.57	0.66	0.83	0.99
AVERAGE	0.08	0.19	0.32	0.44	0.54	0.63	0.79	0.93
STD DEV	0.02	0.02	0.02	0.03	0.04	0.05	0.05	0.05

TABLES OF RESULTS FOR HIGH DEFORMATION TESTS

OAK RIDGE FINS (Series 2): 0.375 inches THICK, 4.0 inches HIGH, 2.0 inches WIDE, 0.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	PERCENT DEFORMATION (%) FROM LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) THEORY	(PEAK ENERGY ABS)/(PLASTIC MOMENT) ACCELRMTR
73481	90.25	547.	49367.	49017.	9290.	33432.	71.5	79.0	18.061	18.190	3.423
73482	90.25	507.	45757.	45461.	16756.	35422.	61.8	67.4	16.750	16.860	6.174
73483	90.25	507.	45757.	45513.	11909.	31939.	69.5	76.4	16.770	16.860	4.388
73484	90.25	507.	45757.	45394.	21152.	33641.	66.8	74.5	16.726	16.860	7.794
73485	90.25	507.	45757.	45420.	11057.	33171.	48.0	50.0	16.735	16.860	4.074

OAK RIDGE FINS (Series 2): 0.375 inches THICK, 6.0 inches HIGH, 2.0 inches WIDE, 0.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	PERCENT DEFORMATION (%) FROM LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) THEORY	(PEAK ENERGY ABS)/(PLASTIC MOMENT) ACCELRMTR
73681	90.25	467.	42147.	41188.	27570.	30959.	74.5	81.0	15.176	15.529	10.158
73682	90.25	467.	42147.	28947.	30911.	28540.	79.7	57.4	10.666	15.529	11.389
73683	90.25	467.	42147.	41924.	19201.	28715.	76.5	81.4	15.447	15.529	7.075
73684	90.25	467.	42147.	41904.	30496.	29566.	77.2	82.4	15.440	15.529	11.237
73685	90.25	467.	42147.	41908.	17366.	31764.	78.5	85.9	15.441	15.529	6.399

OAK RIDGE FINS (Series 2): 0.375 inches THICK, 8.0 inches HIGH, 2.0 inches WIDE, 0.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	PERCENT DEFORMATION (%) FROM LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) THEORY	(PEAK ENERGY ABS)/(PLASTIC MOMENT) ACCELRMTR
73881	90.25	427.	38537.	32435.	17388.	29394.	80.9	75.7	11.951	14.199	6.481
73882	90.25	427.	38537.	32166.	4823.	30373.	76.9	79.2	11.852	14.199	1.777
73883	90.25	427.	38537.	29357.	20831.	27168.	85.3	85.3	10.817	14.199	7.675
73884	90.25	427.	38537.	30005.	26493.	29989.	81.4	81.6	11.056	14.199	9.762
73885	90.25	427.	38537.	32936.	19427.	29473.	83.9	75.3	12.136	14.199	7.158

OAK RIDGE FINS (Series 2): 0.375 inches THICK, 10.0 inches HIGH, 2.0 inches WIDE, 0.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	PERCENT DEFORMATION (%) FROM LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) THEORY	(PEAK ENERGY ABS)/(PLASTIC MOMENT) ACCELRMTR
73181	90.25	387.	34927.	27011.	20494.	28420.	86.3	75.7	9.953	12.869	7.551
73182	90.25	387.	34927.	21217.	22002.	27945.	83.1	33.6	7.817	12.869	8.107
73183	90.25	387.	34927.	19802.	20708.	28112.	73.3	31.7	7.296	12.869	7.630
73184	90.25	387.	34927.	21467.	23348.	27616.	68.2	32.3	7.910	12.869	8.603
73185	90.25	387.	34927.	17939.	27638.	26822.	81.9	34.8	6.610	12.869	10.183

OAK RIDGE FINS (Series 2): 0.375 inches THICK, 4.0 inches HIGH, 2.0 inches WIDE, 0.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	PERCENT DEFORMATION (%) FROM LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) LOADCELL	THEORY	ACCELRMTR
73491	360.00	187.	67320	66123.	41086.	39270.	86.2	87.3	24.364	24.805	15.138
73492	360.00	187.	67320.	66435.	21365.	34075.	73.5	87.1	24.479	24.805	7.872
73493	360.00	187.	67320.	66651.	47894.	48647.	91.2	85.3	24.558	24.805	17.647
73494	360.00	187.	67320.	66324.	42060.	36550.	86.2	97.1	24.438	24.805	15.498
73495	360.00	187.	67320	65492.	36940.	65163.	86.2	86.7	24.131	24.805	13.611

OAK RIDGE FINS (Series 2): 0.375 inches THICK, 6.0 inches HIGH, 2.0 inches WIDE, 0.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	PERCENT DEFORMATION (%) FROM LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) LOADCELL	THEORY	ACCELRMTR
73691	360.00	147.	52920.	52068.	28067.	33030.	81.7	89.6	19.185	19.499	10.341
73692	360.00	147.	52920.	52391.	25209.	30083.	74.5	92.1	19.304	19.499	9.288
73693	360.00	147.	52920.	51864.	18657.	30647.	83.0	90.9	19.110	19.499	6.874
73694	360.00	147.	52920.	52269.	24757.	31788.	79.7	88.5	19.259	19.499	9.122
73695	360.00	147.	52920.	52371.	32268.	28911.	78.5	88.9	19.297	19.499	11.890

OAK RIDGE FINS (Series 2): 0.375 inches THICK, 8.0 inches HIGH, 2.0 inches WIDE, 0.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	PERCENT DEFORMATION (%) FROM LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) LOADCELL	THEORY	ACCELRMTR
73891	360.00	147.	52920.	52224.	11930.	31976.	85.8	94.8	19.242	19.499	4.396
73892	360.00	147.	52920.	52295.	932.	29684.	83.4	98.5	19.269	19.499	0.343
73893	360.00	147.	52920.	52322.	33646.	30286.	84.8	92.3	19.279	19.499	12.397
73894	360.00	147.	52920.	52262.	18218.	27195.	82.9	97.1	19.256	19.499	6.713
73895	360.00	147.	52920.	52278.	13700.	28913.	85.3	101.6	19.262	19.499	5.048

OAK RIDGE FINS (Series 2): 0.375 inches THICK, 10.0 inches HIGH, 2.0 inches WIDE, 0.0 degrees INCLINATION

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM ACCELRMTR	PEAK FORCE PER UNIT FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	PERCENT DEFORMATION (%) FROM LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) LOADCELL	THEORY	ACCELRMTR
73191	360.00	147.	52920.	52313.	21526.	29851.	89.8	99.8	19.275	19.499	7.932
73192	360.00	147	52920.	52289.	28985.	29271.	85.5	99.5	19.266	19.499	10.680
73193	360.00	147.	52920.	52310.	6228.	33605.	83.5	93.5	19.274	19.499	2.295
73194	360.00	147	52920.	46423.	40304.	31842.	80.8	87.4	17.105	19.499	14.850
73195	360.00	147.	52920.	51124.	27750.	32746.	82.7	106.0	18.837	19.499	10.225

OAK RIDGE FINS (Series 2): 0.375 inches THICK, 4.0 inches HIGH, 2.0 inches WIDE, 0.0 degrees INCLINATION

FIN ID NUMBER	ABSORBED ENERGY/(PLASTIC MOMENT) AS A FUNCTION OF PERCENT FIN DEFORMATION (LOAD CELL DATA)							
	10 %	20 %	30 %	40 %	50 %	60 %	70 %	80 %
73481	5.64	8.26	9.60	10.67	12.63	14.67	15.58	
73482	6.69	9.72	11.41	12.68	14.19	16.07		
73483	5.09	7.50	8.89	10.03	12.10	14.16	15.73	
73484	6.56	11.85	14.07	15.35	16.06	16.00	16.01	
73485	6.49	10.19	12.26	13.85	16.54			
AVERAGE	6.10	9.50	11.25	12.51	14.30	15.22	15.77	
STD DEV	0.69	1.70	2.08	2.20	1.98	0.96	0.22	

OAK RIDGE FINS (Series 2): 0.375 inches THICK, 6.0 inches HIGH, 2.0 inches WIDE, 0.0 degrees INCLINATION

FIN ID NUMBER	ABSORBED ENERGY/(PLASTIC MOMENT) AS A FUNCTION OF PERCENT FIN DEFORMATION (LOAD CELL DATA)							
	10 %	20 %	30 %	40 %	50 %	60 %	70 %	80 %
73681	6.24	7.70	8.75	10.00	11.56	12.85	13.95	14.96
73682	5.03	6.08	6.95	8.14	9.51			
73683	4.61	5.81	6.61	7.74	9.78	11.55	12.89	14.11
73684	4.86	6.01	6.95	8.16	10.19	11.58	12.61	13.84
73685	5.62	6.92	7.91	9.03	10.67	11.79	12.80	13.74
AVERAGE	5.27	6.50	7.43	8.61	10.34	11.94	13.06	14.16
STD DEV	0.66	0.79	0.88	0.91	0.81	0.62	0.61	0.55

OAK RIDGE FINS (Series 2): 0.375 inches THICK, 8.0 inches HIGH, 2.0 inches WIDE, 0.0 degrees INCLINATION

FIN ID NUMBER	ABSORBED ENERGY/(PLASTIC MOMENT) AS A FUNCTION OF PERCENT FIN DEFORMATION (LOAD CELL DATA)							
	10 %	20 %	30 %	40 %	50 %	60 %	70 %	80 %
73881	5.49	6.94	7.81	8.79	9.74	10.50	11.14	
73882	4.84	5.62	6.27	7.24	8.86	10.08	10.68	11.20
73883	4.69	5.77	6.30	7.37	8.32	9.05	9.65	10.22
73884	5.21	6.47	7.14	7.47	8.23	10.10	10.47	10.77
73885	5.31	6.72	7.59	8.93	9.84	10.67	11.40	
AVERAGE	5.11	6.30	7.02	7.96	9.00	10.08	10.67	10.73
STD DEV	0.34	0.58	0.71	0.83	0.76	0.63	0.68	0.49

OAK RIDGE FINS (Series 2): 0.375 inches THICK, 10.0 inches HIGH, 2.0 inches WIDE, 0.0 degrees INCLINATION

FIN ID NUMBER	ABSORBED ENERGY/(PLASTIC MOMENT) AS A FUNCTION OF PERCENT FIN DEFORMATION (LOAD CELL DATA)							
	10 %	20 %	30 %	40 %	50 %	60 %	70 %	80 %
73181	4.40	5.27	5.84	6.20	7.42	8.08	8.75	9.33
73182	5.16	6.08	6.84					
73183	5.06	6.09	6.61					
73184	5.31	6.88						
73185	4.53	5.30	5.68					
AVERAGE	4.89	5.92	6.24	6.20	7.42	8.08	8.75	9.33
STD DEV	0.40	0.67	0.57					

OAK RIDGE FINS (Series 2): 0.375 inches THICK, 4.0 inches HIGH, 2.0 inches WIDE, 0.0 degrees INCLINATION

FIN ID NUMBER	ABSORBED ENERGY/(PLASTIC MOMENT) AS A FUNCTION OF PERCENT FIN DEFORMATION (LOAD CELL DATA)							
	10 %	20 %	30 %	40 %	50 %	60 %	70 %	80 %
73491	7.35	10.08	12.36	13.57	14.20	14.63	16.02	18.33
73492	7.41	9.64	12.34	14.06	15.33	17.55	18.64	20.74
73493	7.11	8.37	10.19	10.75	11.59	12.72	13.33	17.18
73494	8.05	13.62	15.96	16.50	15.89	15.87	16.22	15.91
73495	6.95	8.50	10.58	11.12	12.03	13.04	13.76	16.59
AVERAGE	7.37	10.04	12.29	13.20	13.81	14.76	15.60	17.75
STD DEV	0.42	2.13	2.28	2.35	1.93	2.01	2.14	1.89

OAK RIDGE FINS (Series 2): 0.375 inches THICK, 6.0 inches HIGH, 2.0 inches WIDE, 0.0 degrees INCLINATION

FIN ID NUMBER	ABSORBED ENERGY/(PLASTIC MOMENT) AS A FUNCTION OF PERCENT FIN DEFORMATION (LOAD CELL DATA)							
	10 %	20 %	30 %	40 %	50 %	60 %	70 %	80 %
73691	7.13	8.87	9.53	10.58	12.38	12.73	13.08	13.68
73692	7.38	9.21	10.16	11.08	12.56	13.69	14.75	15.66
73693	8.20	10.20	10.97	11.44	11.90	12.36	12.78	13.20
73694	7.16	8.77	9.61	10.70	12.06	13.12	14.21	15.01
73695	7.62	8.97	9.96	11.05	12.58	13.57	14.84	15.69
AVERAGE	7.50	9.20	10.05	10.97	12.30	13.09	13.93	14.65
STD DEV	0.44	0.58	0.57	0.34	0.30	0.56	0.95	1.15

OAK RIDGE FINS (Series 2): 0.375 inches THICK, 8.0 inches HIGH, 2.0 inches WIDE, 0.0 degrees INCLINATION

FIN ID NUMBER	ABSORBED ENERGY/(PLASTIC MOMENT) AS A FUNCTION OF PERCENT FIN DEFORMATION (LOAD CELL DATA)							
	10 %	20 %	30 %	40 %	50 %	60 %	70 %	80 %
73891	6.26	7.29	8.03	9.33	10.28	11.01	11.66	12.33
73892	6.97	8.48	9.80	10.12	10.32	10.46	12.58	13.45
73893	6.29	7.36	7.97	8.78	10.22	10.71	11.64	12.10
73894	6.52	7.84	8.95	9.39	9.37	9.59	11.64	11.77
73895	6.71	7.84	8.46	9.88	10.74	11.48	12.14	12.70
AVERAGE	6.55	7.76	8.64	9.50	10.19	10.65	11.93	12.47
STD DEV	0.30	0.48	0.76	0.52	0.50	0.70	0.42	0.64

OAK RIDGE FINS (Series 2): 0.375 inches THICK. 10.0 inches HIGH. 2.0 inches WIDE. 0.0 degrees INCLINATION

FIN ID NUMBER	ABSORBED ENERGY/(PLASTIC MOMENT) AS A FUNCTION OF PERCENT FIN DEFORMATION (LOAD CELL DATA)							
	10 %	20 %	30 %	40 %	50 %	60 %	70 %	80 %
73191	6.86	8.53	8.90	9.63	10.97	11.60	12.32	13.02
73192	6.09	7.46	7.89	8.47	8.57	9.94	10.83	11.70
73193	7.41	8.50	9.37	9.95	10.09	11.18	12.28	12.84
73194	9.66	11.04	12.75	13.77	14.52	15.38	15.65	15.92
73195	8.13	9.88	10.68	11.22	11.54	12.25	13.82	14.96
AVERAGE	7.63	9.08	9.92	10.61	11.14	12.07	12.98	13.69
STD DEV	1.36	1.39	1.87	2.02	2.19	2.03	1.83	1.71

TABLES OF RESULTS FOR NON-SQUARE IMPACT TESTS

DOUBLE CORNER IMPACT FINS: 0.250 inches THICK, 4.0 inches HIGH, 6.5 inches WIDE, 10. degree HAMMER FACE

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM ACCELRMTR	PEAK FORCE PER UNIT EFFECTIVE FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	PERCENT DEFORMATION (%) FROM LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) THEORY	(PEAK ENERGY ABS)/(PLASTIC MOMENT) ACCELRMTR
92411	135.00	408.	55080.	54696.	54250.	26150.	34.8	24.2	5.536	5.575	5.491
92412	135.00	408.	55080.	54686.	54194.	24639.	36.5	24.1	5.269	5.307	5.222
92413	NO TRACE										
92414	NO TRACE										
92415	135.00	408.	55080.	54679.	54506.	25701.	36.5	24.0	5.269	5.307	5.252

DOUBLE CORNER IMPACT FINS: 0.250 inches THICK, 6.0 inches HIGH, 6.5 inches WIDE, 10. degree HAMMER FACE

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM ACCELRMTR	PEAK FORCE PER UNIT EFFECTIVE FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	PERCENT DEFORMATION (%) FROM LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) THEORY	(PEAK ENERGY ABS)/(PLASTIC MOMENT) ACCELRMTR
92611	135.00	328.	44280.	43998.	43773.	24751.	25.5	17.4	4.045	4.071	4.025
92612	135.00	328.	44280.	44004.	43845.	24200.	25.5	17.2	4.046	4.071	4.031
92613	135.00	328.	44280.	44015.	43902.	22916.	25.5	18.0	4.047	4.071	4.037
92614	135.00	328.	44280.	44007.	43821.	22828.	25.5	17.5	4.046	4.071	4.029
92615	135.00	328.	44280.	43969.	43800.	25743.	25.0	16.1	4.124	4.153	4.108

DOUBLE CORNER IMPACT FINS: 0.250 inches THICK, 8.0 inches HIGH, 6.5 inches WIDE, 10. degree HAMMER FACE

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM ACCELRMTR	PEAK FORCE PER UNIT EFFECTIVE FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	PERCENT DEFORMATION (%) FROM LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) THEORY	(PEAK ENERGY ABS)/(PLASTIC MOMENT) ACCELRMTR
92811	90.25	368.	33212.	32949.	32848.	27644.	15.6	8.9	3.708	3.738	3.697
92812	90.25	368.	33212.	32944.	32826.	31814.	16.1	9.4	3.593	3.622	3.580
92813	90.25	368.	33212.	33002.	32899.	23173.	16.6	11.1	3.491	3.513	3.480
92814	90.25	368.	33212.	32967.	32856.	31326.	15.6	10.0	3.710	3.738	3.698
92815	90.25	368.	33212.	32978.	32886.	26209.	16.6	10.2	3.488	3.513	3.478

DOUBLE CORNER IMPACT FINS: 0.250 inches THICK, 10.0 inches HIGH, 6.5 inches WIDE, 10. degree HAMMER FACE

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM ACCELRMTR	PEAK FORCE PER UNIT EFFECTIVE FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	PERCENT DEFORMATION (%) FROM LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) THEORY	(PEAK ENERGY ABS)/(PLASTIC MOMENT) ACCELRMTR
92111	90.25	408.	36822.	36607.	36484.	24086.	15.6	10.4	3.301	3.320	3.290
92112	90.25	408.	36822.	36638.	36507.	18234.	16.0	11.0	3.221	3.237	3.210
92113	90.25	408.	36822.	36628.	35867.	19220.	16.8	13.0	3.067	3.083	3.003
92114	90.25	408.	36822.	36570.	36381.	26713.	14.6	8.4	3.476	3.500	3.458
92115	90.25	408.	36822.	36644.	36241.	18772.	17.9	13.1	2.880	2.894	2.848

DOUBLE CORNER IMPACT FINS: 0.250 inches THICK, 4.0 inches HIGH, 6.5 inches WIDE, 20. degree HAMMER FACE

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM ACCELRMTR	PEAK FORCE PER UNIT EFFECTIVE FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	PERCENT DEFORMATION (%) FROM LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) THEORY	(PEAK ENERGY ABS)/(PLASTIC MOMENT) ACCELRMTR
92421	135.00	408.	55080.	54510.	52775.	25750.	51.8	46.0	7.297	7.373	7.065
92422	200.00	408.	81600.	80342.	77176.	24680.	61.8	78.3	9.013	9.154	8.658
92423	135.00	408.	55080.	54580.	54228.	35345.	40.0	45.1	9.453	9.539	9.392
92424	NO TRACE										
92425	135.00	408.	55080.	54468.	54150.	51477.	32.3	38.0	11.698	11.830	11.630

DOUBLE CORNER IMPACT FINS: 0.250 inches THICK, 6.0 inches HIGH, 6.5 inches WIDE, 20. degree HAMMER FACE

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM ACCELRMTR	PEAK FORCE PER UNIT EFFECTIVE FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	PERCENT DEFORMATION (%) FROM LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) THEORY	(PEAK ENERGY ABS)/(PLASTIC MOMENT) ACCELRMTR
92621	135.00	328.	44280.	43774.	43543.	42468.	22.0	25.4	9.188	9.295	9.140
92622	135.00	328.	44280.	44080.	44011.	41353.	22.0	25.2	9.253	9.295	9.238
92623	135.00	328.	44280.	44069.	43948.	48104.	22.0	25.1	9.250	9.295	9.225
92624	135.00	328.	44280.	44077.	44001.	45916.	22.0	24.7	9.252	9.295	9.236
92625	135.00	328.	44280.	44082.	43974.	45812.	20.0	24.5	10.181	10.226	10.156

DOUBLE CORNER IMPACT FINS: 0.250 inches THICK, 8.0 inches HIGH, 6.5 inches WIDE, 20. degree HAMMER FACE

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM ACCELRMTR	PEAK FORCE PER UNIT EFFECTIVE FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	PERCENT DEFORMATION (%) FROM LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) THEORY	(PEAK ENERGY ABS)/(PLASTIC MOMENT) ACCELRMTR
92821	90.25	368.	33212.	27.	32877.	127.	11.9	60.5	0.008	9.688	9.591
92822	90.25	368.	33212.	6544.	32904.	7583.	10.5	32.6	2.160	10.961	10.859
92823	90.25	368.	33212.	6649.	32956.	6165.	12.9	39.7	1.789	8.938	8.869
92824	90.25	368.	33212.	6636.	32953.	6114.	13.4	42.5	1.719	8.604	8.537
92825	90.25	368.	33212.	6528.	32967.	5873.	12.9	40.9	1.757	8.938	8.872

DOUBLE CORNER IMPACT FINS: 0.250 inches THICK, 10.0 inches HIGH, 6.5 inches WIDE, 20. degree HAMMER FACE

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM ACCELRMTR	PEAK FORCE PER UNIT EFFECTIVE FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	PERCENT DEFORMATION (%) FROM LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) THEORY	(PEAK ENERGY ABS)/(PLASTIC MOMENT) ACCELRMTR
92121	NO TRACE										
92122	90.25	368.	33212.	6782.	32875.	8392.	7.1	27.8	2.647	12.963	12.832
92123	90.25	408.	36822.	7259.	36487.	5231.	11.8	43.1	1.705	8.648	8.569
92124	90.25	408.	36822.	7262.	36581.	4667.	13.0	43.1	1.548	7.848	7.797
92125	90.25	408.	36822.	7137.	36506.	6028.	11.0	38.3	1.798	9.275	9.195

DOUBLE CORNER IMPACT FINS: 0.375 inches THICK, 4.0 inches HIGH, 6.5 inches WIDE, 10. degree HAMMER FACE

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM ACCELRMTR	PEAK FORCE PER UNIT EFFECTIVE FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	PERCENT DEFORMATION (%) FROM LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) THEORY	(PEAK ENERGY ABS)/(PLASTIC MOMENT) ACCELRMTR
93411	261.00	528.	137808.	136046.	113294.	65817.	31.8	26.9	6.854	6.942	5.708
93412	- - - - - - - - - - - - - - - - - -			NO TRACE	- - - - - - - - - - - - - - - - - -						
93413	261.00	528.	137808.	136282.	112175.	58188.	38.5	23.0	5.662	5.725	4.660
93414	261.00	528.	137808.	135648.	72860.	72059.	32.8	23.3	6.625	6.730	3.558
93415	261.00	528.	137808.	136285.	106972.	63453.	37.5	22.1	5.813	5.878	4.563

DOUBLE CORNER IMPACT FINS: 0.375 inches THICK, 6.0 inches HIGH, 6.5 inches WIDE, 10. degree HAMMER FACE

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM ACCELRMTR	PEAK FORCE PER UNIT EFFECTIVE FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	PERCENT DEFORMATION (%) FROM LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) THEORY	(PEAK ENERGY ABS)/(PLASTIC MOMENT) ACCELRMTR
93611	261.00	488.	127368.	123373.	107795.	71579.	21.0	16.8	6.265	6.467	5.473
93612	261.00	448.	116928.	114837.	103701.	70239.	21.7	15.9	5.651	5.754	5.202
93613	261.00	448.	116928.	114117.	102520.	54024.	23.0	18.7	5.291	5.421	4.753
93614	261.00	448.	116928.	115589.	48233.	69013.	21.0	16.1	5.869	5.937	2.449
93615	261.00	448.	116928.	114490.	105302.	57226.	23.7	18.1	5.159	5.268	4.745

DOUBLE CORNER IMPACT FINS: 0.375 inches THICK, 8.0 inches HIGH, 6.5 inches WIDE, 10. degree HAMMER FACE

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM ACCELRMTR	PEAK FORCE PER UNIT EFFECTIVE FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	PERCENT DEFORMATION (%) FROM LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) THEORY	(PEAK ENERGY ABS)/(PLASTIC MOMENT) ACCELRMTR
93811	204.00	488.	99552.	95443.	88695.	56733.	15.6	12.5	4.885	5.095	4.540
93812	204.00	490.	99960.	96782.	82335.	62365.	16.1	13.1	4.800	4.958	4.084
93813	204.00	488.	99552.	97400.	86392.	69248.	15.1	13.6	5.150	5.264	4.568
93814	204.00	488.	99552.	95293.	88805.	55219.	16.1	13.8	4.726	4.938	4.405
93815	204.00	490.	99960.	96589.	91684.	60943.	16.1	12.4	4.791	4.958	4.547

DOUBLE CORNER IMPACT FINS: 0.375 inches THICK, 10.0 inches HIGH, 6.5 inches WIDE, 10. degree HAMMER FACE

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM ACCELRMTR	PEAK FORCE PER UNIT EFFECTIVE FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	PERCENT DEFORMATION (%) FROM LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) THEORY	(PEAK ENERGY ABS)/(PLASTIC MOMENT) ACCELRMTR
93111	204.00	368.	75072.	73996.	72495.	68455.	11.6	7.3	4.081	4.141	3.999
93112	204.00	448.	91392.	89789.	85885.	70123.	12.0	8.2	4.787	4.873	4.579
93113	204.00	448.	91392.	89212.	81056.	66373.	13.2	8.2	4.324	4.430	3.929
93114	204.00	448.	91392.	89697.	81090.	68444.	12.4	8.2	4.628	4.715	4.184
93115	204.00	448.	91392.	85433.	83351.	62196.	12.8	9.4	4.270	4.568	4.176

DOUBLE CORNER IMPACT FINS: 0.375 inches THICK, 4.0 inches HIGH, 6.5 inches WIDE, 20. degree HAMMER FACE

FIN ID NUMBER	DROP HEIGHT (ins)	HAMMER WEIGHT (lbs)	IMPACT ENERGY (in-lb)	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM LOADCELL	PEAK ENERGY ABSORBED BY FIN (in-lbs) FROM ACCELRMTR	PEAK FORCE PER UNIT EFFECTIVE FIN WIDTH (lbs/in)	PERCENT DEFORMATION (%) MEASURED	PERCENT DEFORMATION (%) FROM LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) LOADCELL	(PEAK ENERGY ABS)/(PLASTIC MOMENT) THEORY	(PEAK ENERGY ABS)/(PLASTIC MOMENT) ACCELRMTR
93421	261.00	528.	137808.	135366.	128163.	84918	43.0	30.8	9.933	10.097	9.391
93422	261.00	528.	137808.	135475.	107815.	89332.	43.0	30.9	9.926	10.097	7.900
93423	261.00	528.	137808.	135998.	116010.	82307.	45.0	29.4	9.521	9.648	8.122
93424	- - - - - - - - - - - - - - - - - - NO TRACE - - - - - - - - - - - - - - - - - -

DOUBLE CORNER-IMPACT FINS: 0.250 inches THICK, 4.0 inches HIGH, 6.5 inches WIDE, 10 degree HAMMER FACE

FIN ID NUMBER	ABSORBED ENERGY/(PLASTIC MOMENT) AS A FUNCTION OF PERCENT FIN DEFORMATION (LOAD CELL DATA)							
	5 %	10 %	15 %	20 %	25 %	30 %	40 %	50 %
92411	0.61	2.13	3.58	4.77				
92412	0.60	2.05	3.45	4.59				
92413	-NO TRACE							
92414	-NO TRACE							
92415	0.55	2.05	3.42	4.53				
AVERAGE	0.59	2.08	3.48	4.63				
STD DEV	0.03	0.05	0.08	0.12				

DOUBLE CORNER-IMPACT FINS: 0.250 inches THICK, 6.0 inches HIGH, 6.5 inches WIDE, 10. degree HAMMER FACE

FIN ID NUMBER	ABSORBED ENERGY/(PLASTIC MOMENT) AS A FUNCTION OF PERCENT FIN DEFORMATION (LOAD CELL DATA)							
	5 %	10 %	15 %	20 %	25 %	30 %	40 %	50 %
92611	1.31	2.84	3.76					
92612	1.31	2.81	3.77					
92613	1.29	2.76	3.70					
92614	1.26	2.78	3.75					
92615	1.37	3.07	4.03					
AVERAGE	1.31	2.85	3.80					
STD DEV	0.04	0.12	0.13					

DOUBLE CORNER-IMPACT FINS: 0.250 inches THICK, 8.0 inches HIGH, 6.5 inches WIDE, 10. degree HAMMER FACE

FIN ID NUMBER	ABSORBED ENERGY/(PLASTIC MOMENT) AS A FUNCTION OF PERCENT FIN DEFORMATION (LOAD CELL DATA)							
	5 %	10 %	15 %	20 %	25 %	30 %	40 %	50 %
92811	2.23							
92812	2.29							
92813	2.08	3.37						
92814	2.40							
92815	2.17	3.45						
AVERAGE	2.23	3.41						
STD DEV	0.12	0.05						

DOUBLE CORNER-IMPACT FINS: 0.250 inches THICK, 10.0 inches HIGH, 6.5 inches WIDE, 10. degree HAMMER FACE

FIN ID NUMBER	ABSORBED ENERGY/(PLASTIC MOMENT) AS A FUNCTION OF PERCENT FIN DEFORMATION (LOAD CELL DATA)								
	5 %	10 %	15 %	20 %	25 %	30 %	40 %	50 %	
92111	2.33	3.24							
92112	2.09	3.12							
92113	2.03	2.87							
92114	2.64								
92115	1.86	2.61							
AVERAGE	2.19	2.96							
STD DEV	0.31	0.28							

DOUBLE CORNER-IMPACT FINS: 0.250 inches THICK, 4.0 inches HIGH, 6.5 inches WIDE, 20. degree HAMMER FACE

FIN ID NUMBER	ABSORBED ENERGY/(PLASTIC MOMENT) AS A FUNCTION OF PERCENT FIN DEFORMATION (LOAD CELL DATA)							
	5 %	10 %	15 %	20 %	25 %	30 %	40 %	50 %
92421	0.89	2.21	3.39	4.20	4.78	5.44	6.57	
92422	0.46	1.57	3.04	4.23	5.16	6.07	7.54	8.14
92423	0.54	2.15	4.07	5.21	6.21	7.11	8.69	
92424	-NO TRACE							
92425	0.65	2.69	5.28	7.26	8.68	9.84		
AVERAGE	0.63	2.15	3.94	5.22	6.21	7.12	7.60	8.14
STD DEV	0.19	0.46	0.99	1.44	1.75	1.94	1.06	

DOUBLE CORNER-IMPACT FINS: 0.250 inches THICK, 6.0 inches HIGH, 6.5 inches WIDE, 20. degree HAMMER FACE

FIN ID NUMBER	ABSORBED ENERGY/(PLASTIC MOMENT) AS A FUNCTION OF PERCENT FIN DEFORMATION (LOAD CELL DATA)							
	5 %	10 %	15 %	20 %	25 %	30 %	40 %	50 %
92621	1.61	4.92	6.56	7.77	9.03			
92622	1.91	5.10	6.47	7.64	8.96			
92623	1.88	5.36	6.77	7.79	9.03			
92624	2.11	5.39	6.60	7.71	9.00			
92625	2.40	5.78	7.64	9.04				
AVERAGE	1.98	5.31	6.81	7.99	9.01			
STD DEV	0.29	0.33	0.48	0.59	0.03			

DOUBLE CORNER-IMPACT FINS: 0.250 inches THICK, 8.0 inches HIGH, 6.5 inches WIDE, 20. degree HAMMER FACE

FIN ID NUMBER	ABSORBED ENERGY/(PLASTIC MOMENT) AS A FUNCTION OF PERCENT FIN DEFORMATION (LOAD CELL DATA)							
	5 %	10 %	15 %	20 %	25 %	30 %	40 %	50 %
92821	-NO TRACE							
92822	0.42	1.16	1.51	1.71	1.90	2.05		
92823	0.38	0.83	1.01	1.15	1.31	1.46	1.72	
92824	0.36	0.81	0.99	1.12	1.26	1.40	1.66	
92825	0.35	0.81	0.99	1.14	1.28	1.42	1.69	
AVERAGE	0.38	0.91	1.12	1.28	1.44	1.58	1.69	
STD DEV	0.03	0.17	0.26	0.29	0.31	0.31	0.03	

DOUBLE CORNER-IMPACT FINS: 0.250 inches THICK, 10.0 inches HIGH, 6.5 inches WIDE, 20. degree HAMMER FACE

FIN ID NUMBER	ABSORBED ENERGY/(PLASTIC MOMENT) AS A FUNCTION OF PERCENT FIN DEFORMATION (LOAD CELL DATA)							
	5 %	10 %	15 %	20 %	25 %	30 %	40 %	50 %
92121	- - -

DOUBLE CORNER-IMPACT FINS: 0.375 inches THICK, 4.0 inches HIGH, 6.5 inches WIDE, 10. degree HAMMER FACE

FIN ID NUMBER	ABSORBED ENERGY/(PLASTIC MOMENT) AS A FUNCTION OF PERCENT FIN DEFORMATION (LOAD CELL DATA)							
	5 %	10 %	15 %	20 %	25 %	30 %	40 %	50 %
93411	0.29	1.42	2.93	4.73	6.30			
93412					-NO TRACE			
93413	0.58	1.71	3.19	4.68				
93414	0.51	1.74	3.26	5.23				
93415	0.62	1.82	3.37	5.02				
AVERAGE	0.50	1.67	3.19	4.92	6.30			
STD DEV	0.15	0.17	0.18	0.26				

DOUBLE CORNER-IMPACT FINS: 0.375 inches THICK, 6.0 inches HIGH, 6.5 inches WIDE, 10. degree HAMMER FACE

FIN ID NUMBER	ABSORBED ENERGY/(PLASTIC MOMENT) AS A FUNCTION OF PERCENT FIN DEFORMATION (LOAD CELL DATA)							
	5 %	10 %	15 %	20 %	25 %	30 %	40 %	50 %
93611	0.75	2.96	5.57					
93612	0.71	2.84	5.45					
93613	0.35	2.15	4.17					
93614	0.37	2.36	5.09					
93615	0.72	2.65	4.48					
AVERAGE	0.58	2.59	4.95					
STD DEV	0.20	0.33	0.61					

DOUBLE CORNER-IMPACT FINS: 0.375 inches THICK, 8.0 inches HIGH, 6.5 inches WIDE, 10. degree HAMMER FACE

FIN ID NUMBER	ABSORBED ENERGY/(PLASTIC MOMENT) AS A FUNCTION OF PERCENT FIN DEFORMATION (LOAD CELL DATA)							
	5 %	10 %	15 %	20 %	25 %	30 %	40 %	50 %
93811	1.39	4.04						
93812	1.40	4.18						
93813	1.41	4.51						
93814	1.30	3.85						
93815	1.31	4.08						
AVERAGE	1.36	4.13						
STD DEV	0.06	0.24						

DOUBLE CORNER-IMPACT FINS: 0.375 inches THICK, 10.0 inches HIGH, 6.5 inches WIDE, 10. degree HAMMER FACE

FIN ID NUMBER	ABSORBED ENERGY/(PLASTIC MOMENT) AS A FUNCTION OF PERCENT FIN DEFORMATION (LOAD CELL DATA)							
	5 %	10 %	15 %	20 %	25 %	30 %	40 %	50 %
93111	2.08							
93112	2.09							
93113	2.00							
93114	2.24							
93115	2.01							
AVERAGE	2.08							
STD DEV	0.10							

DOUBLE CORNER-IMPACT FINS: 0.375 inches THICK, 4.0 inches HIGH, 6.5 inches WIDE, 20 degree HAMMER FACE

FIN ID NUMBER	ABSORBED ENERGY/(PLASTIC MOMENT) AS A FUNCTION OF PERCENT FIN DEFORMATION (LOAD CELL DATA)							
	5 %	10 %	15 %	20 %	25 %	30 %	40 %	50 %
93421	0.54	1.64	3.05	4.98	6.97	8.97		
93422	0.73	1.92	3.53	5.58	7.76	9.53		
93423	0.62	1.75	3.18	5.09	7.09	9.06		
93424	- -				-NO TRACE			
93425	- -				-NO TRACE			
AVERAGE	0.63	1.77	3.25	5.22	7.27	9.18		
STD DEV	0.10	0.14	0.25	0.32	0.43	0.30		

DOUBLE CORNER-IMPACT FINS: 0.375 inches THICK, 6.0 inches HIGH, 6.5 inches WIDE, 20 degree HAMMER FACE

FIN ID NUMBER	ABSORBED ENERGY/(PLASTIC MOMENT) AS A FUNCTION OF PERCENT FIN DEFORMATION (LOAD CELL DATA)							
	5 %	10 %	15 %	20 %	25 %	30 %	40 %	50 %
93621	0.37	1.89	4.31	6.13				
93622	0.82	2.15	3.84	4.58				
93623	1.20	3.27	6.03	8.30				
93624	1.20	3.24	6.08	7.79				
93625	1.39	3.78	6.84	8.80				
AVERAGE	1.00	2.87	5.42	7.12				
STD DEV	0.41	0.81	1.28	1.74				

DOUBLE CORNER-IMPACT FINS: 0.375 inches THICK, 8.0 inches HIGH, 6.5 inches WIDE, 20 degree HAMMER FACE

FIN ID NUMBER	ABSORBED ENERGY/(PLASTIC MOMENT) AS A FUNCTION OF PERCENT FIN DEFORMATION (LOAD CELL DATA)							
	5 %	10 %	15 %	20 %	25 %	30 %	40 %	50 %
93821	2.17	6.62						
93822	1.25	3.95	5.67	6.59				
93823	0.46	2.75	4.78					
93824	1.07	4.20	6.84					
93825	1.49	5.10	7.59					
AVERAGE	1.29	4.53	6.22	6.59				
STD DEV	0.62	1.44	1.24					

DOUBLE CORNER-IMPACT FINS: 0.375 inches THICK, 10.0 inches HIGH, 6.5 inches WIDE, 20. degree HAMMER FACE

FIN ID NUMBER	ABSORBED ENERGY/(PLASTIC MOMENT) AS A FUNCTION OF PERCENT FIN DEFORMATION (LOAD CELL DATA)							
	5 %	10 %	15 %	20 %	25 %	30 %	40 %	50 %
93121	1.79	5.46						
93122	2.18	6.88						
93123	0.60	4.08	5.70					
93124	1.83	6.62						
93125	1.26	5.71						
AVERAGE	1.53	5.75	5.70					
STD DEV	0.61	1.11						

APPENDIX A

CALIBRATION DATA FOR LOADCELLS AND ACCELEROMETERS

APPENDIX A

A.1 Calibration Check of Load Cells

The three load cells used previously were re-calibrated using a Baldwin 400 000 lb Universal testing machine of the Ontario Research Foundation and following the same procedure as before.

Each load cell was calibrated separately by loading it up to a maximum level at a controlled rate and then unloading it, stopping at regular intervals to take readings of strain gauge bridge output. The procedure was repeated twice for each cell. The maximum loading for the three load cells was 35 000 lb [15 900 kg], 150 000 lb [68 180 kg] and 390 000 lb [177 270 kg] respectively. Bridge output readings were taken from the same bridge amplifier used in the experimental tests.

Load cell calibration was done on the 28 Feb 1986 while the testing machine was last calibrated on the 2 Nov 1985.

The calibration curves are presented in Figures A-1, A-2 and A-3.

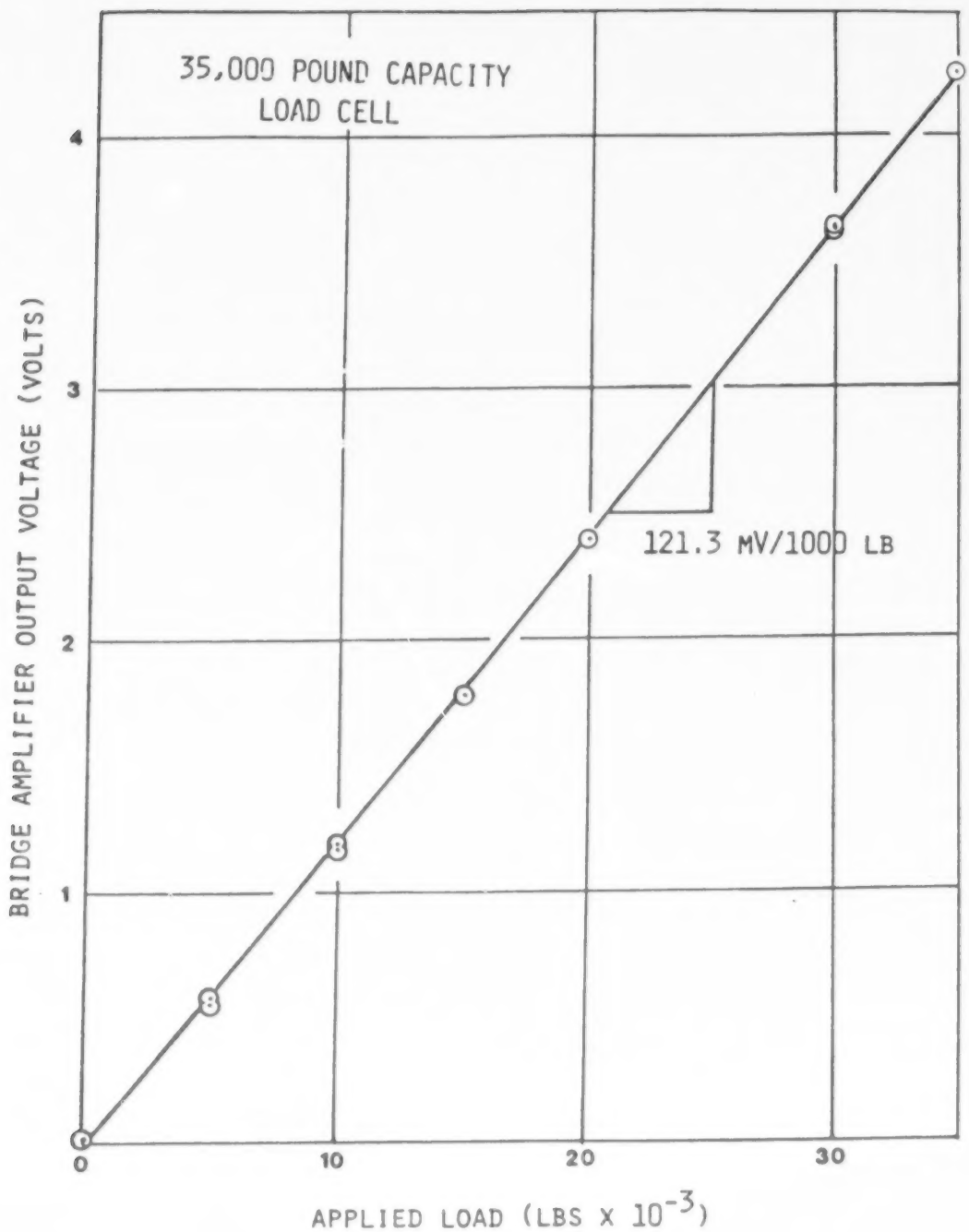


FIGURE A1 - CALIBRATION CURVE FOR 35000 LB LOAD CELL

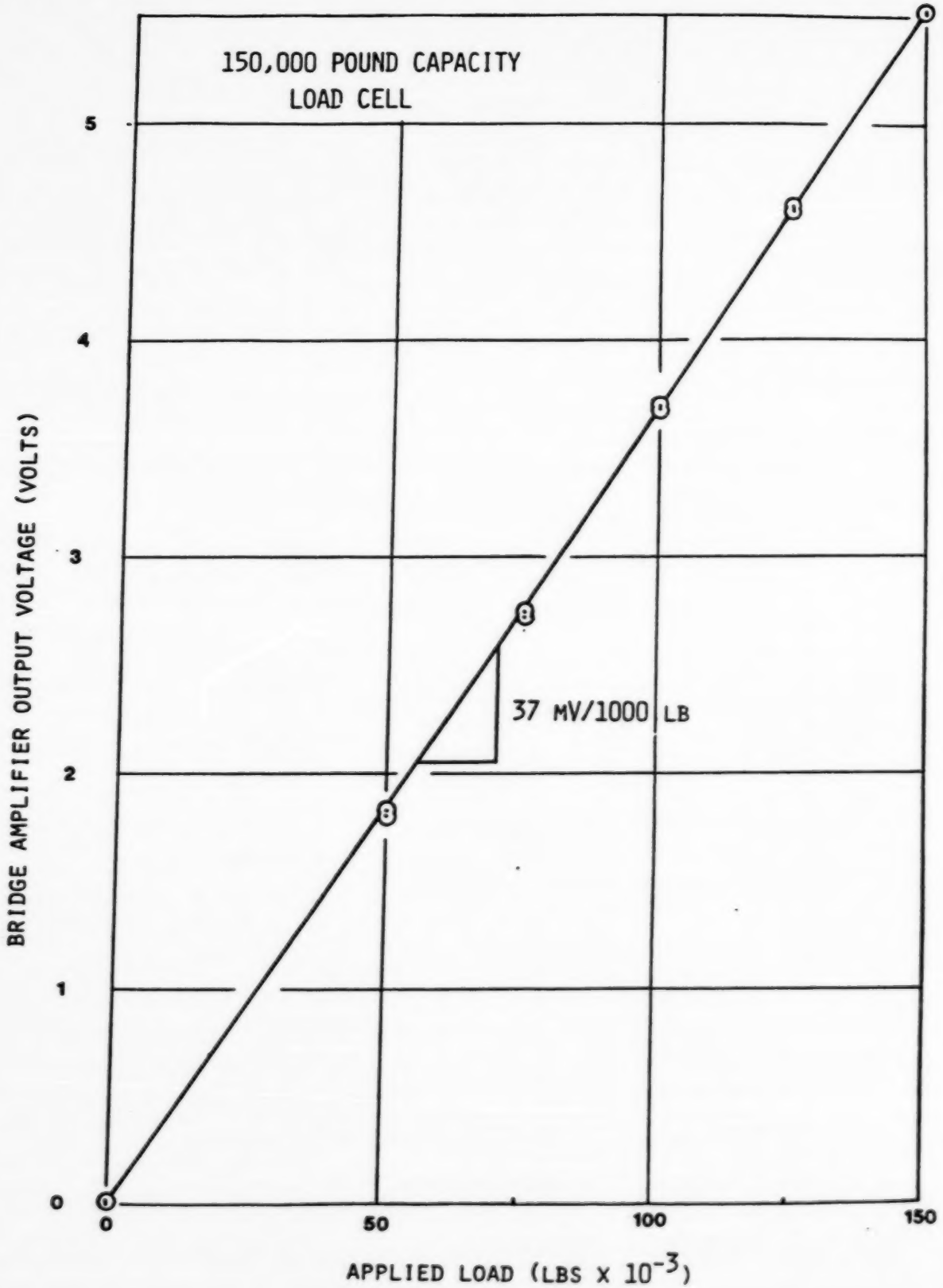


FIGURE A2 - CALIBRATION CURVE FOR 150000 LB LOAD CELL

DURHAM INSTRUMENTS
DIVISION OF TUCHAN INSTRUMENTS, INC.
P. O. BOX 425
PICKERING, ONTARIO L1V 2R7

DYTRAN INSTRUMENTS INC.

Dynamic Transducers and Systems

8523 H Canoga Ave.
Canoga Park, CA 91304
(213) 700-7315

CALIBRATION CERTIFICATE

VOLTAGE MODE ACCELEROMETER

MODEL 3101A NOMINAL SENSITIVITY 10.0 mV/g

SERIAL NO. 245 RANGE, F.S. 500 g

REFERENCE SENSITIVITY
MEASURED AT 100 Hz, 1g RMS 10.2 mV/g

FREQUENCY RESPONSE [1]

FREQUENCY (Hz)	SENSITIVITY DEVIATION (mV/g)
20	9.7
30	10.3
50	10.1
100	10.2
300	10.1
500	10.1
1000	10.1
3000	10.2
5000	10.2
8000	10.2
10000	9.8
12000	9.4

MAXIMUM TRANSVERSE SENSITIVITY 3.0 %

BIAS VOLTAGE 12.7 V

DISCHARGE TIME CONSTANT 7.5 sec

[1] This calibration was performed using the back to back comparison method per ISA S37.2. This calibration is traceable to the N.B.S. test number 737/737001-83.

CUSTOMER: Durham Instruments INVOICE NO. 81403

ORDER NO: 3428A – DATE: 12/30/83

CALIBRATION PERFORMED BY: John J. Kantz

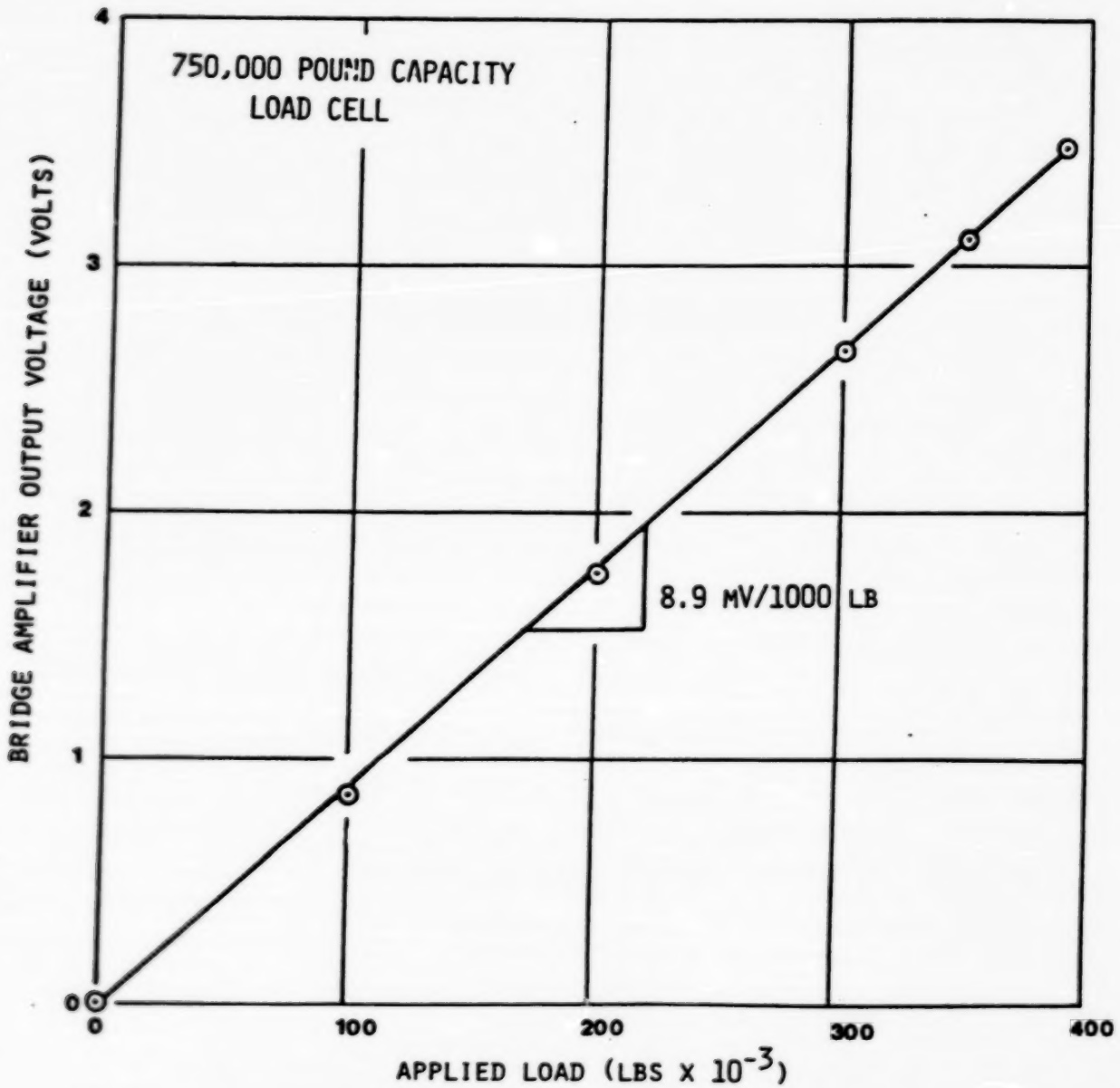


FIGURE A3 - CALIBRATION CURVE FOR 750000 LB LOAD CELL

DURHAM INSTRUMENTS
DIVISION OF DURHAM INSTRUMENTS, INC.
P. O. BOX 426
PICKERING, ONTARIO L1V 2R7,

DYTRAN INSTRUMENTS INC.
Dynamic Transducers and Systems

8523 Canoga Ave Unit I
Canoga Park, CA. 9130(
(213) 700-7818

CALIBRATION CERTIFICATE
PIEZOELECTRIC ACCELEROMETER
LOW IMPEDANCE, VOLTAGE MODE (LIVM)

MODEL 3200A5T RANGE, F.S 5000 G

S/N 188 NOMINAL SENSITIVITY 1.0 mV/g

F.S. OUTPUT VOLTAGE 5.0 VOLTS, NOMINAL

MEASURED SENSITIVITY @ 5000 G LEVEL
0.90 mV/g

RESONANT FREQUENCY, MOUNTED 120 kHz

BIAS VOLTAGE 10.4 VOLTS, DC

THIS CALIBRATION TRACEABLE TO THE NATIONAL BUREAU OF STANDARDS

LABORATORY NO. 232.09/209275

CUSTOMER Durham Instruments INVOICE NO 81403

ORDER NO: 3428A DATE: 12/30/83

CALIBRATION PERFORMED BY: John S. Kanter